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FOREWORD

I am pleased to put into the hands of readers Volume-7; Issue-4: July-August 2022 of **"International Journal of Environment, Agriculture and Biotechnology (IJEAB) (ISSN: 2456-1878)",** an international journal which publishes peer reviewed quality research papers on a wide variety of topics related to **Environment, Agriculture and Biotechnology**. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release issue with DOI (Digital Object Identifier) from CrossRef also, now using DOI paper of the author is available to the many libraries. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind.

I thank all the authors of the research papers for contributing their scholarly articles. Despite many challenges, the entire editorial board has worked tirelessly and helped me to bring out this issue of the journal well in time. They all deserve my heartfelt thanks.

Finally, I hope the readers will make good use of this valuable research material and continue to contribute their research finding for publication in this journal. Constructive comments and suggestions from our readers are welcome for further improvement of the quality and usefulness of the journal.

With warm regards.

Editor-in-Chief
Date: September, 2022

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The ASMC seeder improves maize sowing in the western region of Burkina Faso

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Abstract— *In Burkina Faso, cultivation operations (tillage, sowing, weeding, fertilization, etc.) are mainly carried out by women and young people. Among them, sowing is a particular constraint that determines the success or failure of production. In this country, maize is grown by 78% of producers in the rainy season. In order to improve production, a simple seeder that can be made by local craftsmen was designed as part of the Appropriate Scale Mechanization Consortium (ASMC) project and evaluated with SR21 maize seed in the Koumbia region. It has been harnessed by two oxen. The equipment is evaluated on a plowed plot and on minimum tillage plot. Seed dimensions and distribution disc characteristics were measured. The characteristics of sowing, the traction force and the labor times were measured and compared with those of manual sowing. The results indicate that the sowing time is 3.6 to 3.8 h ha^{-1}, i.e., 8 to 10 times faster than manual practice. The traction force is 22.6 kgf (226 N). That is available for oxen hitch even with one animal. Seed calibration can improve tool performance. The tool has great potential for increasing production if the other production inputs are assured.*

Keywords— ***Seeder, traction force, labor time, maize SR21, plowing***

I. INTRODUCTION

World agricultural production comes mainly from small farms which supply 80% of the products (FAO, 2011). Actors in the agricultural sector are mainly women and young people who are involved in farming activities (tillage, sowing, weeding, fertilization, etc.) as well as in harvesting and post-harvest. Among these activities, sowing is a particular constraint for the producer because it largely determines the success or failure of field production, and itsintensive labor. In the conditions of the Sahel where the rains are irregular at the start of the season, one of the resilience strategies of producers is to carry out the maximum area of sowings during the favorable period. In more arid conditions in the center and north of the country, direct seeding is used. It is imperative to increase cereal production in order to supplied the food needs of growing populations. As the natural resources of this Sahelian zone are limited, the sustainable intensification of cereal production must be an important option (FAO, 2017).

The results of work in 1985 and 1986 on sowing millet with super-eco tool using animal draught in Senegal

showed the importance of this tool for agricultural production (Havard, 1988). In Burkina Faso, this sowing method is more recent, and currently oriented towards direct sowing in the context of conservation agriculture (Cissé, 2013). In recent years, the difficulties encountered by farmers in obtaining labor, particularly because of gold panning, have led them to take an increasing interest in mechanization in general and particularly that of sowing (Lhoste *et al.*, 2002).

In the western region of the country, maize represents a third of the total consumption of cereals (FAO, 2014). Its cultivation is practiced by 78.6% of farms in the rainy season (DPSAA, 2010). In order to improve productivity, a simple seeder that can be made by local craftsmen has been designed as part of the Appropriate Scale Mechanization Consortium (ASMC) project. This study was carried out to evaluate the effectiveness of this equipment in the realization of maize sowing as well as it impacts on the production of this crop in farmers' fields in Koumbia region.

II. MATERIEL AND METHODS

2.1 Study site

The study is carried out in the rural commune of Koumbia (11° 14' 11" North, 3° 41' 47" West), located in the province of Tuy which is in the "Hauts Bassins" region. It is located 67 km northeast of the city of Bobo-Dioulasso. It is bordered to the north by the commune of Houndé, to the south by the commune of Karangasso Vigué, to the west by the commune of Lena and to the east by those of Founzan, Guéguéré and Bondigui (Fig. 1). It has 14 administrative villages.

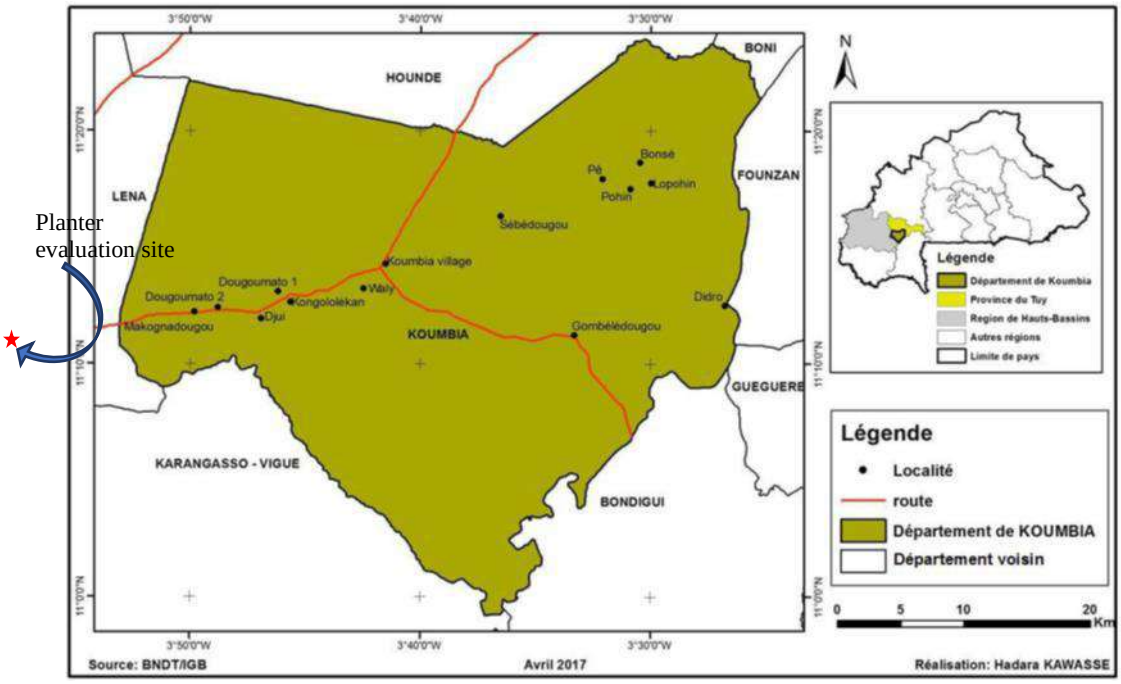


Fig.1: The study site Location (Koumbia)

2.2 Climate and vegetation

The climate is the Sudanian type (Fontès and Guinko, 1995) characterized by the succession of a wet and dry seasons. The rainy season goes from May to October.The average rainfall is around 800 mm to 900 mm as shown by the evolution of rainfall over the last ten years in the commune (Fig. 2).

The most common species are*Acacacia albida, Adansonia digitata, Azadirachta indica, Gmelina arborea, Manguifera sp. Parkia biglobosa, Byturospermum parkii, Anogeissus leocarpus, Lannea acida, Lannea microcarpa, Terminalia avicennoides, Piliostigma thonningii, Zizuphus mauritiana, Prosopis africana, Pterocarpus erinaceus*.Along the streams is dominated by *Mitragyna inermis, Cordia myxa, Nauclea latifolia*. The soils of the department of Koumbia are ferric lixisol on sandy or sandy-clayey materials (FAO, 2006).

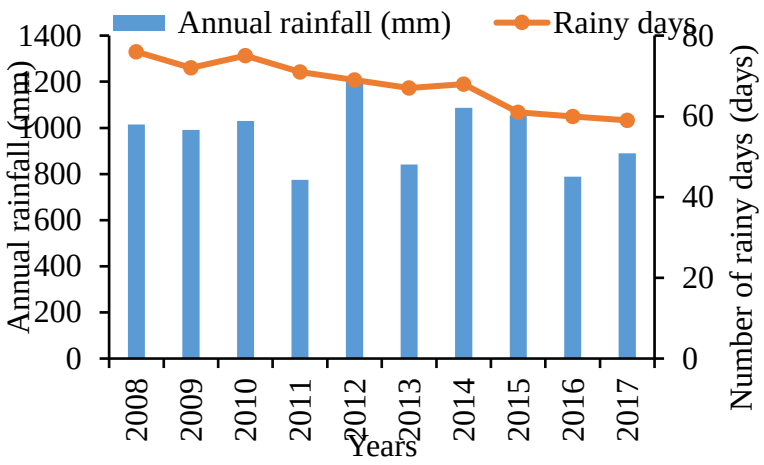


Fig.2: Rainfall over ten consecutive years

2.3 The ASMC maize seeder

The seeder is of the single-row and single-seed type. The theoretical spacing between seed holes is 20 cm. It is animal drawn tool (oxen or donkeys). It can be manufactured by the local craftsmen. It has a hopper that contains a seed distribution disc. This distribution disc is driven by two driving wheels at the front. At the rear there is a press wheel for slightly compacting the soil on the seeds after the opener share and the skimmers close the pits (Fig. 3). In the case of the tests, the animal used is oxen. The theoretical sowing depth is 5 cm.

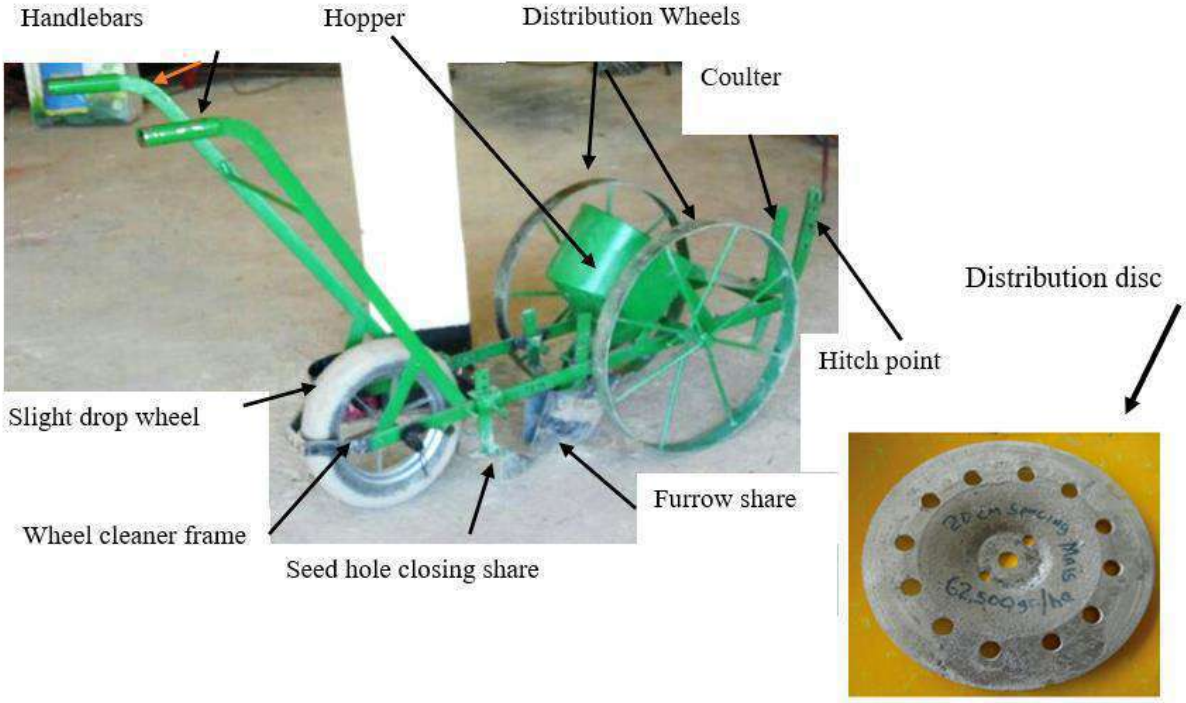


Fig.3: Photography of ASMC maize seeder

2.4 The seed used

The crop seed used is maize's (*Zea mays* L.), variety SR21. It is streak resistant with a potential grain yield of 5.1 t.ha^{-1}. Its sowing maturity cycle is 95 days. The weight of 100 seeds varies from 25 to 33.4 g (Sanou, 2013). The usual seed quantity is 19 kgha^{-1}.

2.5Measurements and observations

- The SR21 maize seed are measured according to the following pattern (Fig. 4).

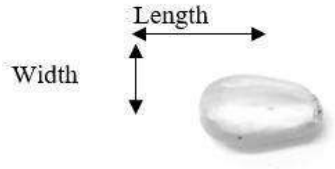


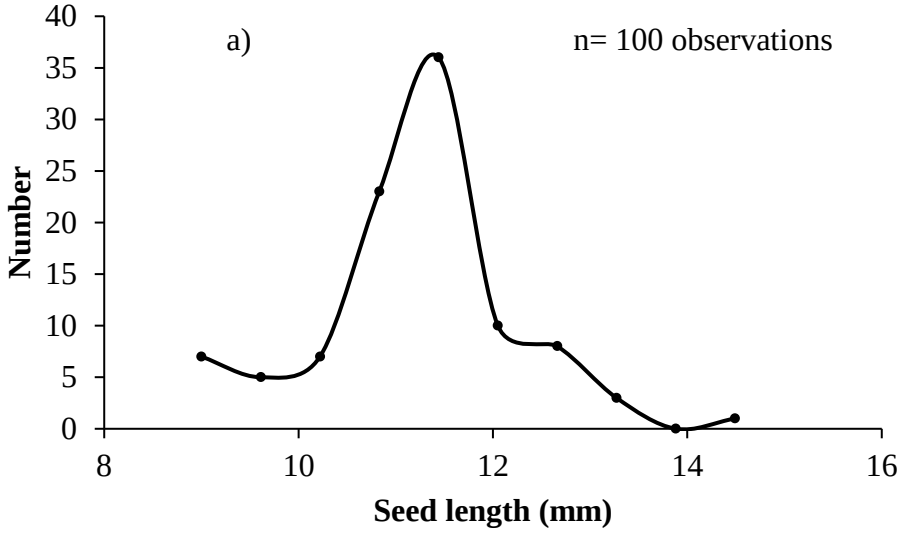
Fig 4:Maize SR21 seed size measure pattern

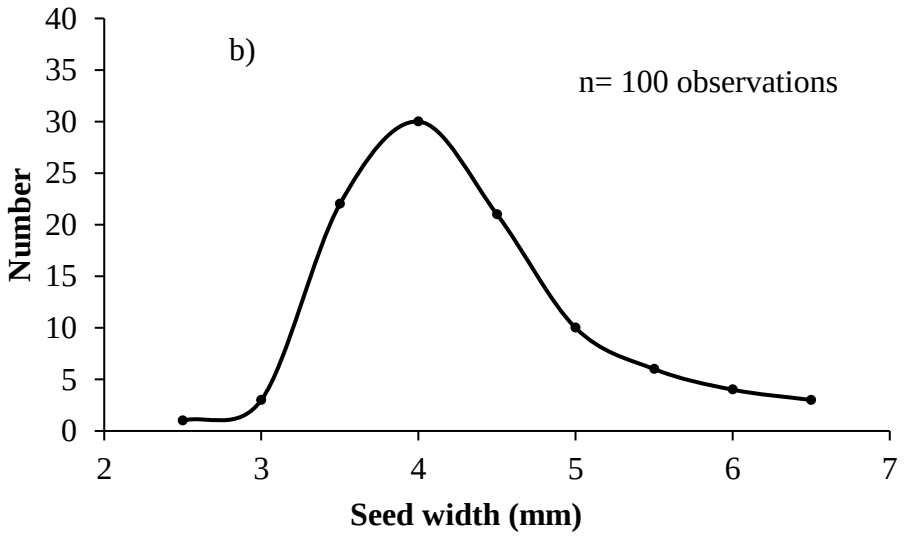
- The spacing between pits is measured between two pits taken at random. The number of observations is 20.
- The number of seeds in the hole is observed on 20 holes.
- The dimensions of the seed distribution disc holes are measured on two old seed distribution disc and one new seed distribution disc.
- The sowing labor time is measured on each elementary plot in four repetitions.Manual sowing is carried out by 7 people and mechanized sowing is done by one seeder and hitch.
- The traction force with a two-oxenhitches measured by 231observations.

III. REsultS

3.1Maize SR21 seed size observed

The measured SR21 maize seeds show that the dimensions are on average 10 to 12 mm in length, 3 to 5 mm in width and 3 to 5 mm in thickness. (Fig 5 a, b, c). This is indicated on graphic a), b) and c).





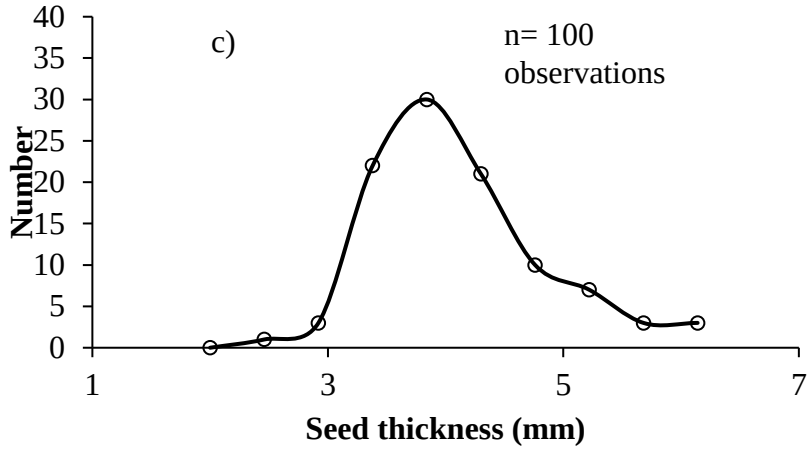


Fig.5: Maize SR21 seeds sizes -a) seed length b) seed width; c) seed thickness.

3.2 The seeds distribution during sowing

The observation of the arrangement of the seed is presented in Table 1. The seed is sown in pits with an average distance of 27.21 cm. The standard deviation between the pits is 13.11 cm. this indicates that in the plot there are pits, 40.32 cm apart and other very close ones only 14.10 cm apart. For the number of seeds per pit, observations indicate that the value is 1 to 2 seeds (Table 1).

Table 1: Seed placement parameter value

Parameter	Mean value	Standard deviation
Distance between pits(cm)	27.21	13.11
Number of seeds by pit	1.24	0.47

n= 20 observations

3.3 Holes size on distribution discs

The results of the analysis of variance indicate that the average depthof the holes of the seed distribution disc are different with a probability P<0.0001 for n= 12. The old version of the seed distribution disc has holes of 4 mm depth than that for the new version the holes have an average of 5 mm (Fig. 6). For the holes diameter of the seed distribution disc there is also a very highly significant difference between the means. For the old version, the holes have a diameter of 13.5 mm while for the new version the holes have a diameter of 13.3 mm (Fig. 7).

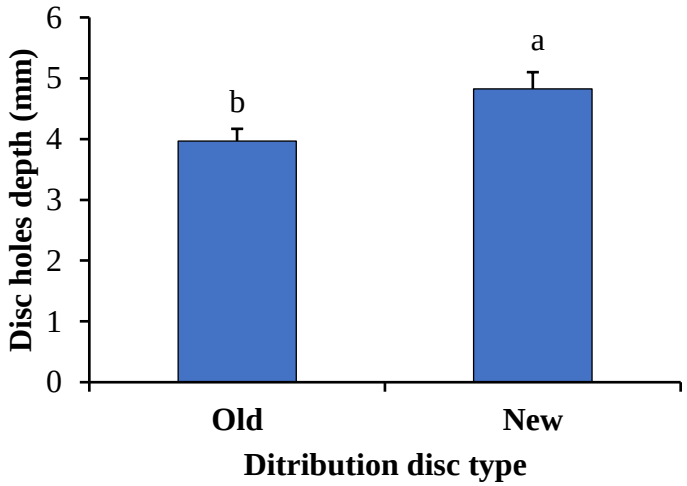


Fig.6: Seed distribution disc holes depth

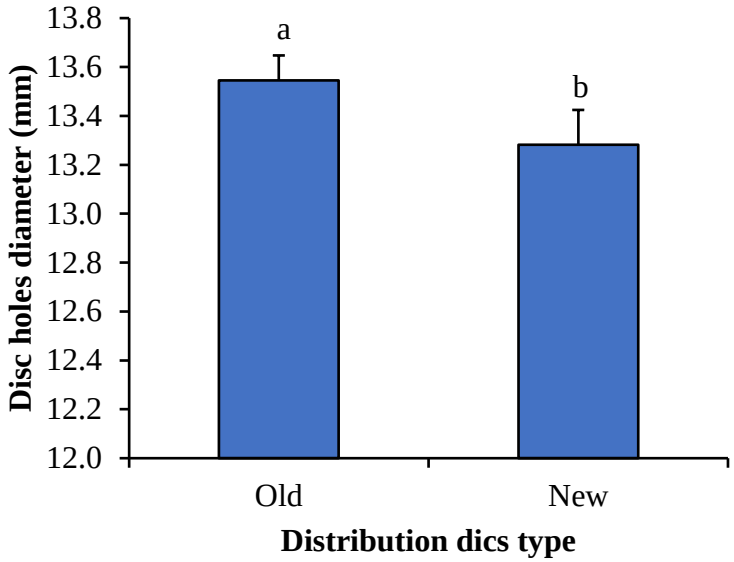


Fig.7: Seed distribution disc holes diameter

a and b indicate different groups of means.

The traction force

Traction force with a cattle hitch varied from 10 to 40.6 DaN. The average is 22.6 ± 6.4 DaN. The number of observations is 235 (Fig. 8).

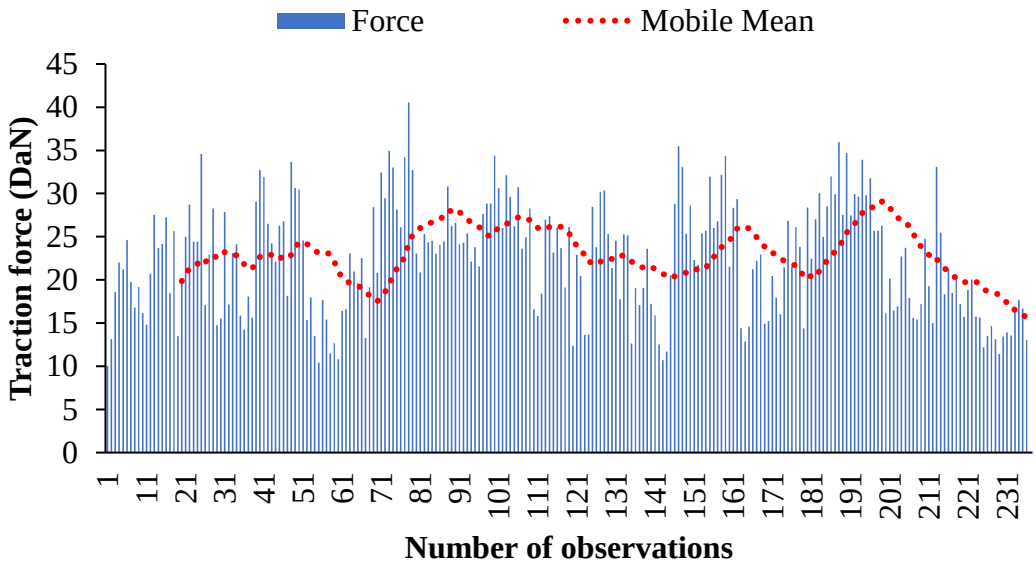


Fig.8: Traction force variation during sowing operation

Mobile mean:20 mobile means of traction force

3.4 Labor time of sowing

The analysis of variance shows that there is and highly significant difference between the average times taken by manual sowing compared mechanized one with the ASMC seeder on the plots of plowing. The probability is 0.001.For minimum tillage plot there is a significant difference between manual and mechanized sowing. The probability is 0.015. It is 0.001 for mechanized sowing

with the ASMC seeder and manual sowing. The interaction between the two factors is also highly significant with P = 0.009.

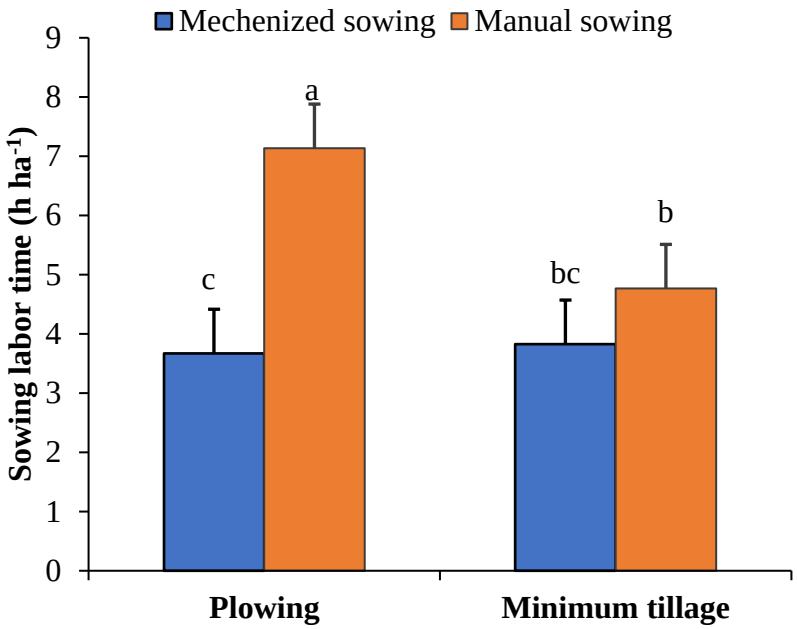


Fig.9: Time taken for sowing on the plots

IV. DISCUSSION

4.1 Seeds distribution by seeder discs

The measurement of the dimensions of the seeds of SR21 maize shows that it has an average length of 11.44 mm and a width of 4 mm for a thickness of 4 mm. The diameter of the seed distribution disc is for the old model is 13.55 mm for a depth of 3.97 mm; for the new seed distribution disc these dimensions are 13.28 mm and 4.82 mm. In 2015, the sowing tests carried out on SR21 maize with the FITARELLI direct seeder with animal traction gave a sample of one seed per pit (Coulibaly *et al.*, 2015). The seederseed distribution disc holeshad diameters of 12.5 and 13.5 mm. The results obtained here are similar to this observation. The old seed distribution disc has a smaller space for taking maize seeds, (169 mm^3). This allows a maize seed to enter the seed distribution disc laterally. Another seed can only enter it upright with little hold on it by the seed distribution disc due to the fact that the inclination of the seed distribution disc in the hopper is approximately 45° (Fig. 3). The new seed distribution disc model had 201 mm^3;20% more volume. This is what led to the significant deposit of seeds in the pit (Sayaogo, 2018; Millogo *et al.*, 2020).

4.2 Seed placing during sowing and crop density

The seeds are sown in the plots at a spacing between pits of 27 cm. This is greater than the theoretical distance of 20 cm. The variation in this distance is significant. The standard deviation represents 48% of the average distance between pits obtained in the field. There is then a problem with the operation of the equipment. With a distance of 20 cm between pits and one seed per pit for sowing 80 cm between rows, the theoretical density would be 62,626 $plantsha^{-1}$. With a spacing of 20 cm between pits and 60 cm between row Kandlil *et al.*, 2017 obtained the best production in Egypt in the Nil delta. In Koumbia, the pedoclimatic conditions differ, the best production is given by sowing at spacingof 27 cm between pits and 80 cm between rows (Sayaogo, 2019). With the spacing between pits obtained of 27 cm for a sowing of 1 seed per pit, the density is 46064 $plantsha^{-1}$. This density value is close to that of Fitsum (2018) with the animal-drawn seeder which obtained a density of 45,000 plants ha^{-1} on maize in Ethiopia. But with 1.24 as the average there will be 57119 plants in the best case. This is different from the recommended density of 5000 to 6000 plants per hectare. If the dose of fertilizer is always the same as that popularized, i.e., 200 kg of $NPKha^{-1}$ and 100 kg of $ureaha^{-1}$, the plants in the plot have more potential nutrients than in conventional production systems. Grain and straw production could be improved.

4.3 The times taken for sowing on the plots and traction force

The time taken for sowing is shorter with the ASMC seeder. It varies from 3 h 42 min to 3 h 48 min whether it is on plowing or minimum tillage for 1 ha. For manual sowing, this time is 7h 06 min when sowing is done on plowing with 7 people for 1 ha. The same operation carried out on the plot of minimum tillage; the time is then 4h 48mn with 7 people. The labor time is then 49 h 48 min 33 h 36 min per ha for manual sowing on plow plot and minimum tillage plot respectively. The difference in time between sowing on the plowing plot and sowing on the minimum tillage is mainly due to the fact that on plowing plot the mobility of the operators more difficult. But mechanized sowing is then 9 to 13 times faster than manual operation. These data are in agreement with those found by Barro *et al.* (2014). This represents a significant time saving in the cropping calendar at this critical phase for producers. The traction force measured during sowing operations indicates that it has a low value. Indeed, according to Vall, (1998) an ox can provide in continuous traction force 10 to 15% of its weight in continuous traction force. According to Millogo *et al.* (2020) draft oxen in the western region have live weight ranging from 227 to 297 kg. The traction force measured during sowing at relatively low values (22.6 DaN on average) makes the seeder usable by a large number of producers using animal traction, whether with cattle or donkey teams. The use of appropriate maize production technology with seeding densities and adequate nutrient supply can increase yields and producer incomes (Lal and Indoriya, 2016). Indeed Sayaogo, (2019) showed that the plants were more vigorous with a grain production of 2780 kg ha^{-1} in the producer's field.

V. CONCLUSION

The ASMC seeder is a tool that allows the producer to sow maize faster than manual practice. On a plowing plot, the seed drill takes 4 hha^{-1} while manual practice takes 33.6 h ha^{-1} for a man. On a plot with minimum tillage, the labor time is 5 hha^{-1} with the seeder, whereas it is 50 h ha^{-1} with manual practice. The required tractive force for the 22.6 daN seeder is available for hitches in the region. The old is shallower than the new. Maize seed must be calibrated to increased seeder efficacity. The use of the ASMC seeder allows the producer to sow 8 to 10 times more area than that carried out manually. Improving other cropping operations will significantly increase maize production, for the western region and all Burkina Faso.

ACKNOWLEDGMENT

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Peer Reviewed

Evaluation of the antimicrobial potential of actinobacteria strains isolated from mangrove soils in the municipality of São Caetano de Odivelas – Pará, Brazil

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Abstract**—***The actinobacteria compose a phylum of Gram-positive bacteria that possess a wide morphological and physiological variety. They are cocci or bacilli shaped and their reproduction is characterized by the formation of spores and septate pseudo hyphae similar to fungi. Physiologically, they have a great capacity to produce secondary metabolites, which give this group of bacteria a high pharmacological and commercial value. The aim of this work was to isolate and evaluate the antimicrobial potential of strains isolated from mangrove soils in the municipality of São Caetano de Odivelas-PA. As results, from the 19 isolates, 11 strains, showed a good performance against the tested pathogenic bacteria - S. aureus, E. coli and K. pneumoniae.*

Keywords**—Actinobacteria; Antimicrobial activity; Bacterial resistance; Mangrove soils.**

I. INTRODUCTION

The bacterial resistance to antibiotics is one of the major global health problems of the 21st century. Studies indicate that superbacteria could lead to about 10 million people dying each year by 2050 (Bastos, 2019). The World Health Organization (WHO) has published a list with 12 families of bacteria that are considered a high degree of threat to human health. The list is divided according to the degree of urgency of the need for new antibiotics, being named in critical, high and medium priority (Who, 2020).

The purpose of the WHO publication is to stimulate the production of new antibiotics, but the development process involved is expensive, requires time and in-depth studies, and requires funding for research and production (Who, 2020). Actinobacteria present themselves as major targets for research of new bioactive compounds due to their great capacity for synthesis of secondary metabolites, presenting high commercial value. Among the genera, *Streptomyces* are the most studied because they are responsible for the production of most of the available antibiotics such as streptomycin, terramycin, aureomycin and others (Anandan; Dharumadurai; Manogaran, 2016).

The phylum actinobacteria comprises one of the largest taxonomic units among the main lineages recognized in the domain Bacteria. They are formed by Gram-positive bacteria and have a high content of guanine and cytosine (G + C) in their genetic material, which, together with the sequencing of the 16S RNA region, are used in studies of the evolutionary relationships between groups of bacteria. As for their morphology, they can be characterized as cocci or rods, and can present highly differentiated mycelia (Barkaet al., 2016; Venturaet al., 2007).

The mangrove is an ecosystem located in coastal regions and considered a transition zone between the terrestrial and

marine environments, developing best in tropical and intertropical zones. This ecosystem has peculiar conditions including the high salinity of the interstitial water, low oxygen concentration of the muddy substrate and daily flooding regime, favoring the development of species adapted to the environment (Brasil, 2018; Saleset al.,2009). In this context, microbial activity plays a key role in contributing to the maintenance of the ecosystem, through the cycling of nutrients due to the processing of organic matter, nutritionally supplying plants and animals living in this environment (Mirandaet al., 2020).

A variety of antibacterial and cytotoxic substances are found in mangroves, which makes this ecosystem an attractive option for the discovery of new bioactive compounds, given that the microorganisms present in this environment have particular physiological processes and metabolites(Yuan; Hong; Lin, 2010;Sangkanuet al., 2017). These characteristics are caused by tidal cycles, humidity, temperature, wave action, UV radiation, nutrients and salinity, making mangrove conditions extreme (Azuma, 2011).

In the last years, research on actinobacteria in environments considered unexplored and extreme, such as mangroves, has increased due to the great diversity and biotechnological activity (Corrêa, 2014). Therefore, the objective of this work is to evaluate the antimicrobial potential of actinobacteria strains isolated from mangrove soils in the municipality of São Caetano de Odivelas - Pará, Brazil.

II. MATERIALS AND METHODS

2.1 Isolation

To isolate the samples, 1g of sample was diluted in test tubes to 10 ml of 0.9% saline solution and submitted to vortex agitation for 5 minutes, after which time they were taken to a centrifuge at 3000 rpm for 5 minutes. The supernatant was seeded with disposable loops by the streak method onto Czapek Dox Agar culture medium.

After primary seeding, the remaining dilution samples were submitted to thermal shock, in which the material was placed in a water bath at 90ºC for 10 minutes and then cooled in the refrigerator at -4ºC for the same period of time and seeding was performed again in order to analyze whether the thermal shock could influence the results found. Petri dishes were incubated in a bacteriological incubator for 24 to 72 hours at a temperature of 35°C ± 2°C and bacterial growth was observed daily.

2.2 Antimicrobial Sensitivity Test

From the isolated actinobacteria, 19 strains were selected to perform two tests to evaluate the antibacterial potential, a direct and an indirect confrontation test, against Gram-positive and Gram-negative bacteria resistant to antibiotics commonly used in clinical practice.

The isolated bacteria were confronted with one strain of *Staphylococcus aureus* (ATCC 25923) and two strains of Gram-negative bacteria from the collection of the Laboratory of Applied Microbiology and Microorganism Genetics of the Pará State University (*Escherichia coli* and *Klebsiella pneumoniae*).

2.2.1 Direct confrontation test

From the multidrug-resistant bacteria, suspensions corresponding to the first tube of the MacFarland scale (105 ufc\mL) were prepared and used to perform mat seeding on a 130mm plate containing Mueller Hinton Agar medium. Subsequently, with the help of an adapted platinum loop, wells of approximately 0.4mm were opened in the culture medium, where fragments of the same size (0.4mm) were implanted from the Czapek Dox Agar culture medium with primary bacterial growth.

The technique was performed with all strains previously selected, which were duly identified and incubated in a bacteriological incubator at 35°C ± 2°C for 24-48h. After the incubation period, the antibacterial potential of the tested actinobacteria was evaluated by measuring, in millimeters, the inhibition halos formed around the colonies.

2.2.2 Indirect confrontation test

A bacterial suspension was prepared with the strains of actinobacteria with a concentration similar to the first MacFarland tube (105 ufc\mL).

The disks impregnated with the actinobacteria strains were positioned on the surface of the Mueller Hinton Agar medium, which was previously seeded by means of the spreading technique with the suspension of multi-resistant bacteria used in the direct confrontation. The bacterial strains were previously identified at the base of the petri dishes. They were then incubated at 35 ± 2°C for 24 to 72 hours. The result was read by measuring, in millimeters, the zone of inhibition formed around the discs.

III. RESULTS AND DISCUSSION

According to Sangkanuet al. (2017), the mangrove ecosystem is a habitat rich in microorganisms with high biotechnological potential. In addition, the review study conducted by Azman et al. (2015), reports that there is still

limited knowledge about mangrove actinobacteria, making this a location of interest for the development of new studies on strains producing bioactive compounds.

The bacterial diversity of this habitat was evidenced in the present study, in which 57.9% (n=11) of the actinobacterial strains isolated from the mangrove of the municipality of São Caetano de Odivelas showed antimicrobial action on the pathogenic bacteria tested. Such diversity was also reported in the study by Lee et al. (2014), in which 55.2% (n=48) of the 87 isolates were able to inhibit the growth of one or more of the bacteria used in the research.

In relation to the Gram positive pathogenic bacteria (*S. aureus*, ATCC 25923), the results were also significant (Fig. 1).Growth inhibition was verified both in direct confrontation (Table 1)and in indirect confrontation (Table 2). The largest inhibition halos were observed against *S. aureus* in both tests, with halos measuring between 7 and 20 mm. Observing, thus, a predominance of antimicrobial activity for gram-positive pathogens demonstrated in several studies such as Hozzeinet al. (2011), Costa (2012), Silva (2012), Corrêa (2014) and Oliveira (2018).

Table 1. Zone of inhibition in mm of the isolated strains tested in direct confrontation.

Direct confrontationtest			
Strain	Zone of inhibition (diameter in mm)		
	K. pneumoniae	*E. coli*	*S. aureus*
SCO3	-	-	20 mm
SCO4A	-	13 mm	16 mm
SCO12	-	8 mm	16 mm
SCO17B	-	-	17 mm
SCO32	-	18mm	-
SCO34A	-	9 mm	-
SCO35B	-	18 mm	14 mm
SCO39	-	16 mm	-

Source:Authorial.

The spectrum of antibacterial action of actinobacteria on gram-positive bacteria may have great importance for the pharmaceutical industry. In the research by Kemunget al. (2020) carried out with strains from a Malaysian mangrove, actinobacteria were found to produce anti-MRSA (*methicillin-resistant Staphylococcus aureus*) substances, to produce biofilms and to have antioxidant activity, indicating the diversity of bioactive compounds produced by bacteria from this ecosystem.

Table 2. Zone of inhibition in mm of the isolated strains tested in indirect confrontation.

Indirectconfrontationtest			
Strain	Zone of inhibition (diameter in mm)		
	K. pneumoniae	*E. coli*	*S. aureus*
SCO 3	-	-	16 mm
SCO 4 A	7 mm	12 mm	15 mm
SCO 12	11 mm	9 mm	16 mm
SCO 17 A	-	-	10 mm
SCO 19 A	-	-	7 mm
SCO 34 A	-	8 mm	14 mm
SCO 35 A	-	10 mm	-
SCO 35 B	-	8 mm	8 mm

Source:Authorial.

Fig. 1: Direct confrontation against S.aureus

Source: Authorial.

The mangrove isolates showed satisfactory results against *E. coli* (Fig. 2 and 3). This result was similar to that study presented Dhawane and Zodpe (2017), in which there was moderate activity against all strains tested. However, the results were different from those obtained by Oliveira (2018), whose actinobacteria isolates showed no antimicrobial activity against Gram negative bacteria.

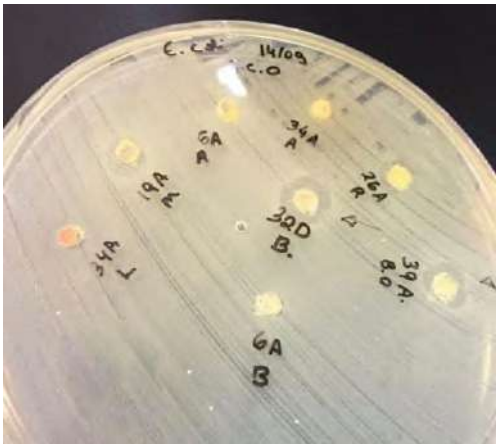

Fig. 2: Direct confrontation test against E.coli

Source: Authorial.

Fig. 3: Indirect confrontation test against E.coli

Source: Authorial.

The reduced activity against Gram-negative bacteria is related to the complexity of the cell wall of these microorganisms, as they have an external membrane that gives them greater resistance to the action of antibiotics, making it impossible to pass the lipid barrier (Silva, 2012; Corrêa, 2014; Nascimento, 2021).

Furthermore, the *K. pneumoniae* strain showed a higher pattern of resistance compared to the other bacteria tested, which can be explained by the presence of a capsule rich in lipopolysaccharides in its structure. This statement can be reaffirmed in the study by Amako, Meno and Takade (1988), in which the authors point out that the capsule may be favorable for protection and resistance against microorganisms in the environment.

The lower spectrum of antibacterial action in direct confrontation compared to indirect confrontation suggests that failures may have occurred during the execution of the technique, such as leveling between the agar block containing the actinobacteria strain and the culture medium, added to that the material used to perform it. Although the technique was adapted from the works of Rincón-enríquez, López-Pérez and Quiñones-aguilar (2014) and Tlemsani et al. (2020), it was noted that there is still a necessity of improvement to obtain satisfactory results in the same way that these authors obtained.

The potential for inhibition of Gram positive bacteria *S. aureus* and Gram negative bacteria *E.coli* corroborates the studies performed by Costa (2012) and Corrêa (2014) with the rhizosphere of Caatinga. Among the microorganisms tested, *K. pneumoniae* was resistant to the metabolites produced by almost all isolates, being sensitive to only two of the isolated strains, in contrast to the results of Costa (2012), in which *K. pneumoniae* was resistant to the metabolites produced by all isolates, which contradicts the study conducted in the Bhitarkanika mangrove in India, in which, of the 15 isolates, 60% inhibited the growth of *K. pneumoniae* (Kishore, 2011).

IV. CONCLUSION

The diversity of actinobacteria present in mangroves is still poorly known due to the difficulties of access and the scarcity of studies focused on these ecosystems. Even so, in the present study, it was possible to identify a great variety of strains of actinobacteria with antimicrobial properties from the mangrove of the municipality of São Caetano de Odivelas-PA, which may have applicability for the research of new antibacterial drugs.The results obtained in the sensibility tests performed were more satisfactory in the indirect confrontation method, highlighting the necessity of improving the direct confrontation technique. Even so, all the results were of great importance for this research and may encourage new studies focused on the bioprospecting of actinobacteria from poorly explored environments.

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Effect of Marketing Mix on Consumer Decisions in Purchasing Pesticide Products Antracol 70 WP in Enrekang Regency (Case Study on Shallot Farmers Using Pesticides in Anggeraja District)

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Abstract— *This study aims to determine the effect of the marketing mix (product, price, promotion, and place) on consumer decisions in purchasing pesticide products Antracol 70 WP in Enrekang district. This research was conducted in Pekalobean Village, Anggeraja District. Enrekang Regency, in February 2022. The respondents in this study were domiciled in Anggeraja Subdistrict, Enrekang Regency as many as 310 farmers. The sampling technique used the simple random sampling method (Simple Random Sampling) as many as 50 respondents. Samples were taken through a questionnaire. The data analysis method used in this research is descriptive analysis. The results showed that the factors that most influence purchasing decisions are product, price, place and lastly promotion. This shows that the product has the largest average value of 4.45 in the "strongly agree" category, meaning that the product greatly influences farmers' decisions to purchase Antracol pesticides, because farmers choose to use Antracol pesticides because the quality of these products has good quality and product suitability farmers want.*

Keywords— ***Marketing Mix, Consumer Decision, Pesticide Antracol 70 wp.***

I. INTRODUCTION

The dynamic development of the business world and the rate of growth population which the more increase fast, push the more increase growth economy. Thing this cause existence competition between companies, including in the field of pesticides, is getting sharper especially in their efforts to market their products well in the form of goods and service to consumer. Marketing in a units effort is wrong one aspect activity which veryimportant in determine continuity life and developmenteffort, as well as determine acquisition profit effort. Strategy formulation marketing could help company maintain the product on position which more good in market so that product could received by consumer. factors which influence and supporting its success is related to the marketing mix.

In meeting consumer needs and desires, companies must be able to study and understand consumer behavior patterns. Understanding consumer behavior patterns can determine the success of the marketing program that is run (Tjiptono, 2010). Furthermore, price and product quality are the main things that consumers pay attention to before making a purchase, they prefer at a relatively affordable price to get quality products, especially products that already have a brand. Marketing activities aim to influence consumers in purchasing a product. In making a purchase, consumers need information about the product to be purchased. To inform the products that have been produced, promotions are carried out.

Pesticides are materials that provide many benefits so that many needed Public on field agriculture (food, plantation, fishery, farm), storage results agriculture, forestry (forest plants and preservation of forest products), house ladder and health environment, settlement, building,transport and etc. In side benefit which given, pesticide also at a time have

potency for could causeimpact which no wanted (Ministry Agriculture, 2011). Farmer use pesticide in farming for push population pest and disease which attack on try it.

The producer must pay attention to the value of the product that has been embedded in the hearts of consumers or further develop it in order to maintain the value of the product itself for consumers. Product attributes are elements that are considered important by consumers and are used as the basis for making decisions to buy a product. According to Peter and Olson (2013) product attributes consist of, price, design, color, quality, features, and product brand. All of these product attributes are important considerations in launching a product, because the product launched is largely determined by the product attributes.

The marketing mix can influence consumer decisions in making purchases. The importance of this marketing mix research is expected to be used to determine whether the four variables in the marketing mix affect consumer decisions in buying pesticides. Because the constraints faced are because each farmer has different abilities, desires and expectations that depend on product quality, price, place, and promotion.

II. METHODOLOGY

2.1 Location and Time Period

This research was conducted in Pekalobean Village, Anggeraja District. Enrekang Regency. The selection of the research location was carried out by *purposive sampling*, namely the determination of the location on the basis of the consideration that Pekalobean Village, Anggeraja District. is a center for producing shallots in Enrekang Regency. This research will be conducted in February 2022 .

2.2 Sampling Method

The population in this study were all shallot farmers who live in Anggeraja District, Enrekang Regency as many as 310 farmers. (Parinsi , 2017). After knowing the population in the research area, the next step is to randomly select a sample of farmers. To determine the sample size of a population can be calculated and using a simple random method (*Simple Random Sampling*). The reference used is the opinion of Suharsimi Arikunto (2004) which says that "for a population whose subjects are less than 100 respondents, it is better to take all of them, so that the research is a population study and then if the number of subjects is more than 100 respondents it can be taken between 10% - 15% of the total population. The sample used in this study were 47 respondents who were rounded up to 50 respondents, using the Slovin formula with e = 0.15 so as to produce 50 respondents.

2.3 Sampling Method

In data collection, the type of data used in this study is primary data. Primary data is data obtained directly from the community either through interviews, observations and other tools. In this study to obtain primary data can be done by distributing questionnaires /questionnaires directly to consumers who use pesticides. The questionnaire /questionnaire was conducted by collecting written data based on the answers from respondents to the questions.

2.4 Data analysis method

The data analysis used in this research is descriptive analysis. Descriptive analysis method that describes and explains the influence of the marketing mix on consumer decisions in purchasing Antracol pesticide products in Enrekang Regency.

In this study, the Likert scale was used. The answers given by the respondents were then scored using the agree-disagree scale technique by developing statements that resulted in agree-disagree answers in various ranges of values. The scoring technique is a minimum of 1 and a maximum of 5, then the calculation of the average answer score is carried out by the following formula (Sugiyono, 2018) .

III. RESULT AND DISCUSSION

Characteristics of Respondents

The data on the characteristics of the respondents in this study are useful for describing the characteristics of the sample obtained from shallot farmers in Pekalobean Village, Anggeraja District, Enrekang Regency, South Sulawesi Province. In this study, the characteristics of the respondents were explained by gender, age, education level, occupation, and income level.

1. Gender

Gender is one of the factors that affect work ability and is also very decisive in the classification of the division of labor . Thus, gender can have an influence on the life rate of a person's life. For more details regarding the population by gender in Pekalobean Village, Anggeraja District, Enrekang Regency, it can be seen in the following table:

Table 1. Total population by gender in Pekalobean Village, Anggeraja District, Enrekang Regency, 2022

No.	Gender	Number of people	Percentage (%)
1	Man	44	88
2	Woman	6	12
	Amount	50	100

Source : Primary Data after processing, 2022.

Based on Table 1 shows that 88% are male, and the remaining 12% are female respondents. Most of the farmers in Pekalobean Village, Anggeraja Subdistrict , are male, because onion farming activities require more men, such as land management, maintenance, fertilization, pest management, harvesting, and post-harvest . This is considered because the man is the head of the family who should work and earn a living. The Central Bureau of Statistics (2010) explained that the head of the household (KRT) is one of the household members who is responsible for meeting daily needs in the household or the elderly/considered/appointed head of household.

2. Age

Age maturity and the ability to think and work are strongly influenced by the age of the farmer. In general, young and healthy farmers have stronger physical abilities and are relatively more receptive to new innovations than older farmers. . Respondent farmers in managing their businesses have different age levels. To find out more about the population by age in Pekalobean Village, Anggeraja District, Enrekang Regency, see table 2 below:

Table 2. Total population by age group in Pekalobean Village, Anggeraja District, Enrekang Regency, 2022.

No	Age (Years)	Number of people	Percentage (%)
1	20-30	9	18
2	31-40	9	18
3	41-50	13	26
4	51-60	12	24
5	61-70	7	14
	Amount	50	100

Source : Primary Data after processing, 2022.

Based on table 2, the majority of farmers in the age range of 41-50 years are 13 people with a total percentage of 26%. It is considered that the productive age of farmers in Pekalobean Village, Anggeraja District, starts from 41 years to 50 years. An explanation of the grouping of different age ranges as evidence that the various age ranges of the population in Pekalobean Village, Anggeraja Subdistrict, make a living as farmers. Susanti, Listiana, & Widayat (2016) explained that farmers aged 30-59 years have physical potential to support farming activities, are dynamic, creative, and fast in accepting new technological innovations. Farmers over 59 years of age have an advantage in terms of experience .

3. Level of education

A person's skills in entrepreneurship and participating in activities in the surrounding environment are partly determined by the level of education, both formal and informal. Therefore, population data based on education is quite important to know. Population data based on education in Pekalobean Village, Anggeraja District, Enrekang Regency, can be seen in table 3 below:

Table 3. Total population by age group in Pekalobean Village, Anggeraja District, Enrekang Regency, 2022

No	Level of education	Number of people)	Percentage (%)
1	SD/Equivalent	15	30
2	Middle School/Equivalent	10	20
3	High School/Equivalent	13	26
4	D3	2	4
5	D4/S1	10	20
	Amount	50	100

Source : Primary Data after processing, 2022.

Table 3 shows that the education level of the respondent farmers, elementary school as many as 15 people with a percentage (30%), junior high school 10 people with a percentage (20%), high school 13 people with a percentage (26%), D3 2 people with a percentage (4%) and D4/S1 10 people with a percentage (20%). This situation is an advancement for the community in the research area. that a higher level of education is an indicator for progress in various business fields, especially in the field of farmers. Progress in education means that it will encourage the creation of new innovations in farming. The family economy is usually influenced by the education that each family has (Wahyu Apriliyawati, 2017).

4. Work

Most of the residents in Pekalobean Village, Anggeraja Subdistrict, Enrekang Regency are farmers. However, not all residents in Pekalobean Village, Anggeraja Subdistrict, Enrekang Regency make a living as farmers because there are also some people whose livelihoods are farmers, housewives, and civil servants. For more details, see the Table

Table 4. Total population by type of work in Pekalobean Village, Anggeraja District, Enrekang Regency, 2022

No	Type of work	Number of people)	Percentage (%)
1	Farmer	39	78
2	Housewife	6	12
3	civil servant	5	10
	Amount	50	100

Source : Primary Data after processing, 2022.

Based on Table 4, it can be seen that the largest occupation is residents with jobs as farmers, which is 78%. This is in line with the statement (Trisnawati et al., 2018) that the most dominant work in rural areas is in the agricultural sector. Likewise, in Pekalobean Village, Anggeraja District, in general the population has a livelihood as farmers. In addition, there are a small number of respondents who have main jobs outside of agriculture as housewives and civil servants.

5. Income Level

Income is the income obtained by farmers from farming less expenses for farming. Income can influence the decision-making process. Based on the level of income can be seen in Table 5 below :

Table 5. Total population by income level in Pekalobean Village, Anggeraja District

No	Income Level	Total (Org)	Percentage (%)
1	<Rp. 1,000,000	15	30
2	IDR 1,000,000 - IDR 2,000,000	20	40
3	IDR 3,000,000 – IDR 5,000,000	15	30
	Amount	50	100

Source : Primary Data after processing, 2022.

Based on Table 5, it can be seen that the variable income level with the most income is Rp. 1,000,000 – 2,000,000 as many as 20 people with a percentage of 40%, income <Rp. 1,000,000 as many as 15 people with a percentage of 30%, and an income of IDR 3,000,000 - 5,000,000 as many as 15 people from 50 respondents with a percentage of 30%. This shows that people who have high incomes are farmers who mostly buy pesticide products Antracol 70 WP considering that farmers prioritize quality, so the higher the farmers' income, it will influence farmers to make decisions in purchasing pesticides.

This is in accordance with the opinion (Sirait Fauzi, 2016) that the ability to make purchases of a product can be influenced by consumer income. The higher a person's income, the ability to make large purchases, be it the quantity of the product or the price of the product needed.

Validity test

Validity test is used to measure the determination or accuracy of a research instrument. To determine whether or not an item is used, it can be tested significantly.

Table 6. Validity Test

Variable		R Value Calculate	Table R Value	Value Significance	Information
	$X_{1.1}$	0.714	0.279	0.000	Valid
	$X_{1.2}$	0.577	0.279	0.000	Valid
Product (X_1)	$X_{1.3}$	0.634	0.279	0.000	Valid
	$X_{1.4}$	0.718	0.279	0.000	Valid
	$X_{2.1}$	0.759	0.279	0.000	Valid
Price (X_2)	$X_{2.2}$	0.768	0.279	0.000	Valid
	$X_{2.3}$	0.636	0.279	0.000	Valid
	$X_{3.1}$	0.782	0.279	0.000	Valid
Promotion (X_3)	$X_{3.2}$	0.768	0.279	0.000	Valid
	$X_{3.3}$	0.579	0.279	0.000	Valid
Place (X_4)	$X_{4.1}$	0.714	0.279	0.000	Valid
	$X_{4.2}$	0.577	0.279	0.000	Valid
	$X_{4.3}$	0.634	0.279	0.000	Valid
Purchase Decision (Y)	$Y1_{\_}$	0.718	0.279	0.000	Valid
	$Y2_{\_}$	0.759	0.279	0.000	Valid
	Y_3	0.768	0.279	0.000	Valid
	Y_4	0.636	0.279	0.000	Valid
	Y_5	0.782	0.279	0.000	Valid
	Y_6	0.768	0.279	0.000	Valid
	Y_7	0.579	0.279	0.000	Valid

Source: Primary data after processing, 2022

Based on Table 6, the results of the validity test of each indicator of product, price, place and promotion variables on consumer decisions in purchasing Antracol 70 WP pesticide products, the correlation coefficient value is greater than r table. With n = 50 at a significance level of 5% r table = 0.279 so that it can be declared valid.

Reliability Test

An instrument is said to be reliable if a person's answer to the statement in the questionnaire is consistent or stable from time to time. To determine the reliability of a statement, the SPSS 25 computer program was used, to obtain the *Cronbach Alpha value* for each research variable. The test results can be said to be reliable if *Cronbach Alpha* > 0.600 (Imam Ghozali, 2007:41)

Based on this description, it is necessary to test the reliability of each variable, where the data is processed with the help of SPSS 25.

Table 7. Reliability Test

Variable	Cronbach's Alpha	Information
Product	0.692	real
Price	0.755	real
Promotion	0.755	real
The place	0.640	real
Buying decision	0.840	real

Source: Primary data after processing, 2022

Based on the data in table 7 above, it shows that the numbers from the *Cronbach Alpha (a) value* on all variables in this study, all of them show a magnitude above the value of 0.600. This means that all statements for the independent and dependent variables are reliable and it can be concluded that the questionnaire statement instrument shows reliability in measuring the variables in the research model.

Descriptive Analysis

Descriptive analysis aims to provide an overview of the respondents' level of agreement on all questionnaire items. The level of approval of the questionnaire was expressed in the form of strongly disagree, disagree, neutral, agree, strongly agree. While the variable items tested are product, price, promotion, and place.

Product Variable Descriptive

A product is anything that can be offered to a market for attention, purchase, use, or consumption that might satisfy a want or need. In this study, the product variables were measured with 4 indicators as follows:

Table 8. Respondents' Responses Regarding Products

No	Question Items	Score Frequency	Score					Amount	Average
			TB	KB	CB	B	SB		
1	How is the quality of the pesticide antracol 70 WP?	Frequency	0	0	5	18	27	50	4.44
		F x Score	0	0	15	72	135	222	
2	How about packing	Frequency	0	0	3	25	22	50	
	in the form of bottles or packs on antracol 70 WP pesticide?	F x Score	0	0	9	100	110	219	4.38
3	How to Label information about dose use and ingredient active antracol 70 WP pesticide, has the explanation been completed? complete and detailed?	Frequency	0	0	3	25	22	50	
		F x Score	0	0	9	25	22	219	4.38
4	Is the quality of antracol 70 WP pesticide effective?	Frequency	0	0	0	20	30	50	
		F x Score	0	0	0	80	150	230	4.6
Average									4.45

Source: Primary data processed, 2022

From table 8 it is known that the respondents' answers regarding product variables with an average number of 4.45 and in the "Very good" category means that Antracol pesticide products have good quality, quality and packaging and have complete and detailed information labels on dosage and use. .

Thus, product variables with product quality indicators, product packaging, and information labels on dosage and product use have been assessed and approved by consumers.

Price Variable Descriptive

Price is the amount of money exchanged for a product or service. Price, which is the only element of the marketing mix that is often used as a consideration for consumers in making purchases, cannot be ruled out by companies. In this study the price variable is measured by 3 indicators as follows:

Table 9. Respondents' Responses Regarding Prices

No	Question Items	Score Frequency	Score					Amount	Average
			TM	KM	CM	BM	SM		
1	How do you respond Mr/mother about fairness price of pesticide antracol 70 WP ?	Frequency	0	0	3	21	26	50	4.46
		F x Score	0	0	9	84	130	223	
2	What is your opinion regarding the pricing of antracol 70 WP pesticide?	Frequency	0	0	7	29	14	50	
		F x Score	0	0	21	116	70	207	4.14
3	How is the price of antracol 70 WP pesticide compared to the price of other pesticides?	Frequency	0	0	3	35	12	50	
		F x Score	0	0	9	140	60	209	4.18
Average									4.26

Source: Primary data processed, 2022

From table 9 it is known that the respondents' answers regarding the price variable with an average amount of 4.26 and in the "Agree" category, meaning that the price of Antracol pesticide products, most of the respondents agree that the price of Antracol pesticides is in accordance with the quality. This is because the quality of Antracol pesticides is in accordance with the price paid by farmers so that farmers are not disappointed with the results they get. So, the variable Price with indicators of price fairness with product quality, pricing, and comparison of prices of Antracol pesticides with other pesticides.

Promotional Variable Descriptive

Promotion is one of the variables in the marketing mix that companies must do to provide information about their products or services, as well as persuade and remind consumers to make purchases of goods and services. In this study, the promotion variable was measured with the following indicators:

Table 10. Respondents' Responses Regarding Promotion

No	Question Items	Score Frequency	Score					Amount	Average
			TS	KS	CS	S	SS		
1	How attractive is the advertising message (the superiority of anthraol 70 WP pesticide) that delivered through magazines and the internet today?	Frequency	0	0	6	26	18	50	4.24
		F x Score	0	0	18	104	90	212	
2	How to attract sales promotion anthracol 70 WP pesticide ?	Frequency	0	0	9	36	5	50	
		F x Score	0	0	27	144	25	196	3.92
3	How is the diversity of mass media used in promoting antracol 70 WP pestisida pesticide through advertising?	Frequency	0	0	18	28	4	50	
		F x Score	0	0	54	112	20	186	3.72
Average									3.96

Source: Primary data processed, 2022

From table 10 it is known that the respondents' answers regarding the promotion variable with an average number of 3.96 and in the "Interesting" category means that the promotion makes consumers interested in trying, consumers feel helped by the existence of information in print and electronic media with a fairly frequent frequency so that able to provide complete information about advertised products to farmers. Thus, the promotion variable with promotion indicators aims to influence consumer behavior, inform and educate consumers, remind consumers that they have been judged to agree.

Description of Place Variables

Location is a decision made by the company regarding where its operations and staff will be considered, and location is a combination of location and decisions on distribution channels . In this study, the location variable was measured by 3 indicators as follows:

Table 11. Respondents' Responses Regarding Place

No	Question Items	Score Frequency	Score					Amount	Average
			SM	M	CM	M	SM		
1	How is the number of channeling agents or pesticide seller antracol 70 WP ?	Frequency	0	0	7	28	15	50	4.16
		F x Score	0	0	21	112	75	208	
2	How is the distance between home and point of sale anthracol 70 WP pesticide ?	Frequency	0	0	8	26	16	50	
		F x Score	0	0	24	104	80	208	4.16
3	How easy is it to get / buy pesticides antracol 70 WP ?	Frequency	0	0	17	12	21	50	
		F x Score	0	0	51	48	105	204	4.08
Average									4.13

Source: Primary data processed, 2022

From table 11, it is known that the respondents' answers regarding the place variable have an average number of 4.13 and are in the "adequate" category, meaning that the location of Antracol pesticide products has easy access for farmers to make it easier for farmers when farmers want to get these products. Then the place variable with indicators that have a number of channeling agents, the distance traveled is also not too far, making it easier for farmers if they want to buy these products.

Description of Purchase Decision Variables

Purchase decision is a consumer's decision to buy a product after previously thinking about whether or not it is appropriate to buy the product by considering the information he knows with the reality about the product after he has seen it. In this study, the purchasing decision variables were measured by 7 indicators as follows:

Table 12. Respondents' Responses Regarding Purchase Decisions

No	Question Items	Score Frequency	Score					Amount	Average
			TS	KS	CS	S	SS		
1	In your opinion, is the pesticide antracol 70 WP able to fulfill the requirements? coping needs pests?	Frequency	0	0	5	16	29	50	4.48
		F x Score	0	0	15	64	145	224	
2	After you know Regarding the pesticide antracol 70 WP, are you looking for additional information before buying the pesticide?	Frequency	0	0	8	23	19	50	
		F x Score	0	0	24	94	95	213	4.26

3	How is the price level of antracol 70 WP pesticide with other types of pesticides?	Frequency	0	0	9	18	23	50	
		F x Score	0	0	27	72	115	214	4.28
4	How is the quality of the pesticide antracol 70 WP different from other types of pesticides?	Frequency	0	0	0	24	26	50	
		F x Score				96	130	226	4.52
5	How much influence in deciding your purchase by looking at attribute product (packaging, packaging color, brand identification and information labels) which are considered stand out ?	Frequency	0	0	7	19	24	50	
		F x Score			21	76	120	217	4.34
6	After you bought the pesticide antracol 70 WP, how would you rate the pesticide as a whole in terms of quality, price and benefits?	Frequency	0	0	3	32	15	50	
		F x Score	0	0	9	128	75	212	4.24
7	Do you think it is good for you to recommend buying antracol 70 WP pesticide to your colleagues ?	Frequency	0	0	9	26	15	50	
		F x Score	0	0	27	104	75	206	4.12
		Average							4.32

Source: Primary data processed, 2022

From table 12 it is known that the respondents' answers regarding the purchasing decision variables with an average number of 4.32 and in the "Strongly Agree" category. This means that consumers buy Antracol pesticide products because by looking at the influence of the marketing mix, namely product, price, promotion and place. Then the purchasing decision variables with indicators are able to meet the needs of pest control , seek additional information before buying pesticides, such as the price level of pesticides, and the difference in the quality of the type of pesticide with other pesticides.

The Effect of Products on the Purchase Decision of Antracol 70 WP Pesticides.

Products are all things that can be offered to the market to attract attention, acquisition, use or consumption that can satisfy a want or need (Kotler and Armstrong, 2018). The product is the whole concept of an object or process that provides some consumer value. Likewise, purchasing decisions when in an economic situation affect product choices.

Based on the research results indicate that the product variable with an average number of 4.45 and in the "very good" category, which means that the higher the quality of the product, the higher the purchasing decision will be. Antracol 70 WP pesticide product is in the quality category. It can be seen that some respondents stated that the quality of Antracol pesticide was seen in terms of the color of the Antracol pesticide packaging, including the attractive one, as well as the information label on the dose of use and active ingredients of the Antracol pesticide, the explanation was complete and detailed. The quality of Antracol pesticides is also in accordance with the wishes and able to compete with other products. The results of this study are also supported by Paul Petter & Jerry C. Olsson (2018) that products and product characteristics are the main stimulants that influence consumer affection, cognition, and behavior in purchasing decisions. Consumers tend to buy products with known brands because they will feel safe, avoid various risks with the assumption that known product brands are more reliable.

The Effect of Price on the Purchase Decision of Antracol 70 WP Pesticide.

Price is the amount of value that customers exchange for the benefits of owning or using a product or service whose value is set by the buyer or seller and set by the seller for the same price to all buyers (Staton, in Tjiptono 2015). Marketers do need to focus on the entire buying process, not just the buying decision.

Basically, purchasing decisions are strongly influenced by purchase motives where it can be because buyers make purchases, carry out purchases only for emotional considerations, such as pride, suggestions, and so on. But also buyers buy rationally like the price.

Based on the results of the study, it shows that the respondents' answers regarding the price variable with an average amount of 4.26 and in the "Agree" category, meaning that the price of Antracol pesticides is appropriate because many respondents agree that the price of Antracol

pesticides given is in accordance with the quality, and is competitive. This is because the quality of Antracol pesticides is in accordance with the price paid by farmers so that farmers are not disappointed with the results they get. And also Antracol pesticides according to the purchasing power of consumers in the surrounding environment.

The results of this study are also supported by the opinion of Tjiptono (2008) that consumers in purchasing decisions will consider the price, information about prices is needed and the information obtained will affect consumer behavior.

Effect of Promotion on Purchase Decision of Antracol 70 WP Pesticide.

In addition to competitive prices and quality products in terms of packaging and contents, producers must also carry out promotional activities to introduce their products so that they are better known and closer to farmers. Promotional activities that have been able to influence farmers to purchase Antracol pesticides include the intensive advertising activities carried out by producers both through print and electronic media with a fairly frequent frequency so that they are able to provide complete information about advertised products to farmers.

The results showed that the respondents' answers regarding the promotion variable with an average number of 3.96 and in the "Interesting" category, meaning that the promotion made consumers interested in trying it, consumers felt helped by the existence of information in print media with a fairly frequent frequency so that they were able to provide information. complete information about the products advertised to farmers. This means that the more promotions make consumers interested in trying, the more consumers feel helped by the information on social media and the more consumers always remember it, the more purchasing decisions will be made.

The results of this study are also supported by Tjiptono (2008) which states that promotion is one of the determining factors for the success of a marketing program, no matter how quality a product is if consumers have never heard of it and are not sure that the product is useful for them, then they will never buy it.

Influence of Place on Purchase Decision of Antracol 70 WP Pesticide.

According to Tjiptono (2015) it refers to various marketing activities that seek to expedite and facilitate the delivery or distribution of goods and services from producers to consumers. Location can influence consumers in making purchasing decisions. With the proximity of the location to the consumer, the consumer will be greatly helped when the consumer wants the product and can go directly to the location and enjoy the desired product.

Based on the results of the analysis, it is known that the respondents' answers regarding the place variable with an average number of 4.13 and in the "Adequate" category, meaning that most respondents agree that the selection of agent locations for Antracol pesticides has easy access for farmers. This is because the location of the purchase of Antracol pesticides with residential areas and easy access to farmers can make it easier for farmers when farmers want to get these products.

Influence of Product, Price, Promotion and Place on Purchase Decision of Antacol 70 WP . Pesticide

Purchasing decision is the consumer's process in making a decision to buy a product provided by a producer that can meet the needs and desires of consumers, while the purchase decision referred to in this study is a series of decision-making processes carried out by consumers in order to choose an item, namely the pesticide product Antracol 70 WP.

The results showed that the factors that most influence purchasing decisions are product, price, place and lastly promotion. This shows that the product has the largest average value of 4.45 in the "strongly agree" category, meaning that the product greatly influences farmers' decisions to purchase Antracol pesticides, because farmers choose to use Antracol pesticides because the quality of these products has good quality and product suitability. farmers want. So that farmers in Anggeraja village have Antracol pesticide compared to other pesticides.

IV. CONCLUSION

Based on the results and discussions that have been stated, it is concluded that:

1. The product variable with an average number of 4.45 is in the "very good" category, meaning that if the quality of the product is higher, the purchasing decision will be higher as well.
2. The price variable with an average amount of 4.26 in the "Agree" category means that if Antracol pesticide products are in accordance with the quality, farmers are not disappointed with the results obtained so that they will increase purchasing decisions.
3. The promotion variable with an average number of 3.96 and in the "Interesting" category means that the more the promotion makes consumers interested in trying, the more consumers feel helped by the information on social media, the more purchasing decisions will be made.
4. The place variable with an average number of 4.13 and in the "adequate" category means that most respondents agree that the selection of an agent location for Antracol pesticides has easy access for farmers, it will further improve purchasing decisions.

5. The results showed that the factors that most influence purchasing decisions are product, price, place and lastly promotion. This shows that the product has the largest average value of 4.45 in the "strongly agree" category, meaning that the product greatly influences farmers' decisions to purchase Antracol pesticides, because farmers choose to use Antracol pesticides because the quality of these products has good quality and product suitability. farmers want.

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An Examination of a Major All Cargo Airline Energy Management: The Case of Cargolux Airlines International

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Abstract**—***Based on the use of a qualitative longitudinal research design, this study examines Cargolux Airlines International, a major global air cargo airline, sustainable energy management. The study covers the period 2012 to 2020. Cargolux Airlines International energy sources are aircraft (Jet A1) aircraft fuel, diesel, cooling energy, electricity, heating energy, industrial fuel, natural gas, and unleaded gasoline 95. The case study revealed that Cargolux's Jet A1 fuel consumption has principally exhibited an upward trend reflecting the growth in the airline's services, route network expansion, and the growth in the aircraft fleet during the study period. Cargolux Airlines International annual cooling energy consumption (kWh) oscillated over the study period reflecting differing cooling requirements. Cargolux Airlines International annual diesel consumption fluctuated quite markedly during the study period reflecting differing vehicle fuel consumption requirements and usage. The case study found that there was a general downward trend in Cargolux Airlines International annual electricity consumption during the period 2012 to 2015, whilst there was a general upward trend in the airline's electricity consumption from 2016 to 2020. The airline's annual heating consumption also oscillated over the study period reflecting differing heating requirements. Cargolux Airlines International annual industrial fuel consumption primarily displayed a general downward trend. The airline's annual natural gas consumption has fluctuated throughout the study period reflecting differing consumption patterns at the airline. Cargolux annual 95 gasoline consumption displayed a general downward trend from 2012 to 2015, and a general upward trend from 2015 to 2020. Throughout the study period, Cargolux Airlines International implemented a range of energy savings measures that enabled the airline to optimize its energy consumption.*

Keywords**—** ***All-cargo airlines, case study, Cargolux Airlines International, energy consumption, sustainable airline energy management.***

I. INTRODUCTION

The air transportation of goods/freight for commercial purposes plays a very vital role in the global economy and the global supply chain (Alemán, 2010; Dewulf et al., 2019; Heng, 2016; Lee et al., 2019). In the world air cargo industry, air cargo capacity is provided by combination passenger airlines, all-cargo airlines, and the integrated carriers. three distinct types of airline operators (Baxter, 2021a; Baxter & Wild, 2021). Combination passenger airlines are airlines that carry passengers on the main deck and transport air cargo in their passenger aircraft lower lobe belly-holds. Some combination airlines, for example, Cathay Pacific Airways, Korean Airlines, Qatar Airways, and Singapore Airlines, also operate freighter aircraft in addition to their passenger services. Shippers may also decide to use dedicated all-cargo airlines, for example, Cargolux International Airlines or Nippon Cargo Airlines (NCA). The final type of air cargo carrying airline operator is the integrated carriers, for example, DHL Express, FedEx and United Parcel Service (UPS) (Baxter & Wild, 2021; Dresner & Zou, 2017; Merkert & Alexander, 2019). All-cargo services are operated with freighter aircraft where all the available capacity is dedicated to air cargo transportation (Dresner & Zou, 2017; Tretheway & Andriulaitis, 2016). A freighter aircraft is an aircraft that has been expressly designed or which has been converted

to transport air cargo, express, and so forth, rather than passengers (Wensveen, 2016). Dedicated all-cargo services play a very significant role in the aviation industry, and to the global economy (Davies, 2013). Freighter aircraft carry around 56 per cent of global air cargo revenue ton kilometres (RTKs) (Boeing Commercial Airplanes, 2020).

Cargolux International Airlines, one of the world's major global all cargo airlines, was selected as the case airline in this study due to its long-term commitment to sustainable energy management. The sustainable management of its energy consumption is a key part of the airline's sustainability policy. The objective of this paper is to analyze how Cargolux International Airlines manages its aircraft fuel and ground-based facility energy consumption. A further objective of the study is to examine the energy savings measures implemented by Cargolux International Airlines to optimize its energy consumption, and thus, mitigate its impact on the environment. The study period was from 2012 to 2020.

The remainder of the paper is organized as follows: The literature review is presented in Section 2. Section 3 describes the study's research methodology that underpinned the study. The case study is presented in Section 4. Section 5 outlines the study's conclusions.

II. BACKGROUND

2.1 Airline Jet Fuel Consumption

The global airline industry is highly energy intensive (Baxter et al., 2021). Jet fuel accounts for the major share of an airline's energy consumption. There are various types of jet fuel used in the airline industry as well as for military aviation. During the 1960s, Jet-A fuel became the standard fuel used in the United States and by many commercial airlines (Brooks et al., 2016). This type of fuel was selected over the more highly flammable JP-4 for passenger safety reasons (Yildirim & Abanteriba, 2012). Jet A-I fuel is available globally, including in the United States (Brooks et al., 2016). Jet fuel typically represents the highest cost for an airline (Turner & Lim, 2015; Vasigh & Rowe, 2020).

2.2 Aircraft Fuel Efficiency

Growing environmental concerns has motivated the air transport industry to the judicious use of aviation fuel. As a result, both economic and environmental sustainability concerns have led to significant improvements in aviation fuel efficiency in recent times (Singh et al., 2018). In the global airline industry, airlines want to fly the most efficient aircraft possible, and thus, saving fuel inflight plays a key role for airlines (Hardiman, 2022). According to Oliveria et al. (2021), "fuel efficiency has become one of the most important policy goals for airline operations management". To improve aircraft fuel efficiency, airlines and the aircraft manufacturers have invested in recent times in new technologies and strategies to reduce aircraft fuel consumption (Zou et al., 2016).

At a worldwide level, the peak airline industry body – the International Air Transport Association (IATA) – have recognized the requirement to address the global challenge of climate change and has subsequently adopted a set of ambitious targets to mitigate carbon dioxide (CO_2) emissions from air transport. The association has targeted an average improvement in aircraft fuel efficiency of 1.5% per year from 2009 to 2020. IATA has implemented a multi-faceted approach: the four-pillar strategy to ensure that this objective is met (International Air Transport Association, 2021a). The strategy entails:

- Improved technology, including the deployment of sustainable low-carbon fuels.
- More efficient aircraft operations.
- Infrastructure improvements, including modernized air traffic management systems.
- A single global market-based measure, to fill the remaining emissions gap (International Air Transport Association, 2022a).

The term fuel efficiency for an airline refers to the consumption between the observed and least possible volume of fuel consumed in the production of a given level of output for the airline. Due to the complexity of airline operations, fuel efficiency is dependent upon a range of factors including aircraft size, market characteristics (short-haul versus long-haul services), service network structure (hub-and-spoke or point-to-point [P2P]), and so forth (Zou et al., 2016, p. 320). Fuel efficiency is also largely dependent upon aircraft fuel burn, the average aircraft speed, and other technical design factors. It is important to note that fuel efficiency can be controlled by an airline by the flying techniques that are employed, the distances flown, as well as other variables (Vasigh et al., 2012).

2.3 Airline Ground Service Equipment (GSE) Energy Consumption

To perform ground handling services of aircraft when they are being serviced on the ground in between flights, sophisticated technical equipment is required to perform the aircraft turnaround handling (Ashford et al., 2013; Kazda & Caves, 2015; Roberts, 2018). The ground service equipment (GSE) used in servicing an aircraft includes push-back tugs, lower deck loaders, (main deck loaders for freighter aircraft), toilet and water truck, tugs (for towing cargo to and from the air cargo terminal and for towing

baggage to and from the airport's baggage makeup area), aircraft container and pallet dollies, ground power unit, aircraft tail stand (for freighter aircraft), and aircraft bulk hold loaders (Baxter et al., 2021). Ground service equipment (GSE) refers to vehicles and equipment that are used in the airport precinct to service whilst they are at the gate in between flights (Hazel et al., 2011). Ground service equipment (GSE) is generally powered by diesel or petrol engines. Vehicles used by airlines are also often petrol-powered (Baxter et al., 2021).

2.4 Airline Property and Facilities Energy Consumption

To support their operations, airlines typically have extensive ground-based properties and facilities. These buildings include office buildings, aircraft and ground service equipment (GSE) maintenance facilities and hangars, air cargo terminals, and flight catering centres. As a result, airlines require a reliable and highly efficient source of energy to power their airport and non-airport located buildings, facilities, and equipment. Electrical power is also required to run machinery, heating, ventilating, and air conditioning (HVAC) systems, building lighting, computers and so forth (Baxter et al., 2021).

Aside from leasing airport terminal(s), airlines can potentially be one of several tenants in other airport-located multi-tenant buildings (Crider et al., 2011). Airports are very energy-intensive areas (Baxter et al., 2018; Ortega Alba & Manana, 2017; Sreenath et al., 2021). Thus, an airline's airport operations can be extremely energy intensive (Baxter et al., 2021).

III. RESEARCH METHODOLOGY

3.1 Research Approach

This study used a qualitative longitudinal research design (Derrington, 2019; Hassett & Paavilainen-Mäntymäki, 2013; Neale, 2019). The key objective of a longitudinal research design is to collect and analyze qualitative data on growth, change, and development over time. The major advantage of this research approach is that it reveals change and growth in an outcome over time (Kalaian & Kasim, 2008).

3.2 Data Collection

The data used in the study was obtained from a range of documents, company materials available on the internet and records as sources of case evidence. Documents included the Cargolux International Airlines Annual Reports, Cargolux International Airlines Annual Sustainability Reports, and the airline's websites. A comprehensive search of the leading air cargo and air transport journals and magazines was also conducted in the study. A search of the SCOPUS and Google Scholar databases was also performed in the study.

The key words used in the database searches included "Cargolux environmental policy", "Cargolux sustainability policy", "Cargolux annual aircraft fuel consumption, "Cargolux annual cooling energy consumption", "Cargolux annual diesel consumption", "Cargolux annual electricity consumption", "Cargolux annual heating energy consumption", "Cargolux annual industrial fuel, "Cargolux annual natural gas consumption", "Cargolux annual unleaded gasoline 95 consumption "Cargolux membership of CORSIA", "Cargolux's use of sustainable aviation biofuels", and "Cargolux energy conservation measures".

The study therefore used secondary data. The three principles of data collection as recommended by Yin (2018) were followed: the use of multiple sources of case evidence, creation of a database on the subject and the establishment of a chain of evidence.

3.3 Data Analysis

The qualitative data collected for the case study was examined using document analysis. Document analysis is a research technique that is regularly used in case study research (Baxter, 2021a). Document analysis focuses on the information and data from formal documents and company records that are gathered by a researcher when conducting their study (Andrew et al., 2011; Yin, 2018). Following the guidance of Scott (2014) and Scott and Marshall (2009), the documents collected for the present study were examined according to four key criteria: authenticity, credibility, representativeness and meaning.

The document analysis was conducted in six discrete stages. The first phase involved planning the types and required documentation and ascertaining their availability. The second phase involved gathering the documents and developing and implementing a scheme for the document management. Following the conclusion of Phase 2, the documents were reviewed to assess their authenticity, credibility and to identify any potential bias. In Phase 4, the content of the collected documents was interrogated, and the key themes and issues were identified. Phase 5 involved reflection and refinement to identify any difficulties associated with the documents, reviewing sources, as well as exploring the documents content. The analysis of the data was completed in Phase 6 of the document analysis process (O'Leary, 2004).

The documents gathered for the study were downloaded and stored in a case study database (Yin, 2018). The documents were all in English. Each document was

carefully read, and key themes were coded and recorded (Baxter, 2021b).

IV. RESULTS

4.1 A Brief Overview of Cargolux Airlines International

Cargolux Airlines International commenced commercial operations in March 1970 when it began operating world-wide air cargo charter services from its home base located at Luxembourg's Findel Airport (Green & Swanborough, 1975). At the time if its inception, Cargolux's shareholders were Luxembourg's national airline Luxair, Swedish shipping line Salen Shipping Group, Icelandic airline Loftleider Icelandic and private interests (Buyck, 2004). Each shareholder held a third of the shares with the balance held by private interests (Belson, 1977). Cargolux began operations in May 1977 (Flight International, 1979) with a single Canadair CL-44D4 aircraft (Belson, 1977; Nelms, 1996).

Cargolux took delivery of its first jet-powered aircraft, a McDonnell Douglas DC8-61F, in 1973. The first Boeing 747-200F freighter aircraft joined the airline's fleet in 1979. The airline also added two Boeing B707-331 "combi aircraft" to its fleet in 1979. In 1985, Cargolux withdrew its fleet of McDonnell Douglas DC8F and Boeing 707' aircraft, and in the process became Europe's first all Boeing 747-200F air cargo operator (Nelms, 1996).

Cargolux took delivery of its first Boeing B747-400 freighter aircraft in 1993. This aircraft model provided Cargolux with a better range capability and increased air cargo capacity (Nelms, 1996). Cargolux was the first all-cargo airline to take delivery of the Boeing B747-400 freighter aircraft. Initially, it was envisaged that the Boeing B747-400F would rationalize the Cargolux fleet. This fleet rationalization would be achieved through operating its fleet of Boeing B747-200 freighter aircraft on shorter routes and the Boeing 747-400 freighter aircraft on longer air routes. However, costs savings arising from the operation of a two-crew cockpit, 18% fuel savings, lower maintenance costs, and greater capacity of the Boeing B747-400 led to the decision to replace the Boeing 747-200 fleet with the Boeing B747-400 freighter aircraft (Air Transport World, 1998).

Cargolux Airlines International together with Japan-based Nippon Cargo Airlines (NCA) were the launch customers for the Boeing 747-8 freighter aircraft (Ostrower, 2011). Following the orders for 13 Boeing 747-8 freighters by Cargolux and 14 by Nippon Cargo Airlines, Boeing officially launched the 747-8F program (Conway, 2012). Cargolux took delivery of its first Boeing 747-8 aircraft on October 12, 2011 (Boeing Commercial Airplanes, 2011).

At the time of the present study, Cargolux Airlines International operated a fleet of 14 Boeing 747-8 freighters, 10 Boeing 747-400 and 6 Boeing 747-400ERF freighter aircraft (Cargolux Airlines International, 2021a). The airline's worldwide route network covers some 75 destinations. In addition to its scheduled flights, Cargolux also operates full and part-charter services as well as aircraft maintenance services (Cargolux Airlines International, 2021b).

Cargolux Airlines International established a joint venture all cargo airline Cargolux Italia S.p.A with Italian-based interests in December 2008. The airline operates a fleet of four Boeing B747-400 freighter aircraft (Cargolux Italia, 2021).

Figure 1 presents Cargolux Airlines International annual enplaned air cargo tonnage and freight tonne kilometres performed (FTKS) for the period 2012 to 2020. According to Daley (2016, p. 36), a freight tonne kilometre (FTK) is defined "as the mass of air cargo multiplied by the distance that the cargo is carried". Cargolux's annual enplaned air cargo tonnage and FTKs grew from 644,613 tonnes and 5.2 billion FTKs in 2012 to 1,107,071 tonnes and 8.934 billion FTKs in 2020 (Figure 1). From 2012 to 2018, the airline has recorded growth in both their annual enplaned air cargo tonnage and FTKs performed reflecting the patronage of the airline (Figure 1). Figure 1 shows that the airline's enplaned freight tonnage and freight tonne kilometres performed (FTKs) declined in 2019. World air cargo demand declined in 2019 and the air cargo modes performance was dampened by the weak growth in world trade of just 0.9% (International Air Transport Association, 2020). Cargolux International Airline's enplaned freight tonnage and freight tonne kilometres performed (FTKs) returned to positive growth in 2020 (Figure 1).

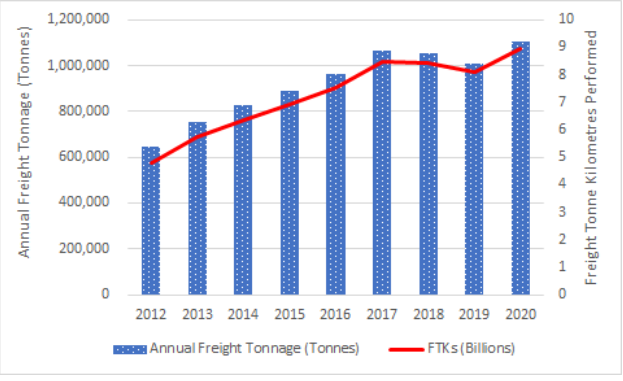

Fig.1: Cargolux Airlines Airline's annual enplaned freight tonnage and freight tonne kilometres performed (FTKs): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021b)

4.2 Cargolux Airlines International Sustainability Policy and Related Measures

Throughout its history, Cargolux Airlines International has taken responsibility for its impact on climate change and the role that commercial air transport plays on the environment. As a result, the airline has a policy of operating a fleet of the most environmentally friendly and energy efficient freighter aircraft. The company has also sought to mitigate its environmental impact at its office and facilities through energy savings measures and the strengthening of environmental awareness amongst its employees. Cargolux has adopted near and long-term goals that are in accordance with the International Air Transport Association (IATA) targets for airlines to reduce carbon dioxide (CO_2) emissions with the ultimate objective of achieving carbon neutral growth (Cargolux Airlines International, 2017a).

Cargolux Airlines International has implemented an Environmental Management System (EMS) that establishes and monitors key environmental performance indicators. Cargolux's Environmental Management System (EMS) is in accordance with the requirements of the ISO 14001:2015 certification standard (Cargolux Airlines International, 2015). ISO 14001 is a worldwide meta-standard for implementing Environmental Management Systems (EMS) (Dentch, 2016; Grover & Grover, 2017; Heras-Saizarbitoria et al., 2011).

On 20 October 2006, Cargolux Airlines International signed a "Charter on Corporate Social Responsibility and Sustainable Development agreement". The Charter incorporates an important element of modern management by which large firms and corporations not only have a responsibility to the many stakeholders that are affected by the firm's activities, including its employees, customers, the local community, and the environment. With this Charter, Cargolux acknowledged its responsibilities, and the company stressed its commitment towards supporting the well-being and the sustainable development of each stakeholder and the environment (Cargolux Airlines International, 2007).

The environmental dimension of the Charter stipulates that the signatory firm undertakes to:

- Minimize the impact of its activities on the environment by controlling its usage of water, power and raw materials, by restricting its waste production and by promoting recycling.
- The firm should select its partners, suppliers, and sub-contractors according to ecological criteria, that is, good environmental practices, and/or offer of goods and services that are beneficial to the environment; and
- The firm should encourage its employees to travel to work by means of transport that limit the damage to the environment (public transport, car-pooling, bicycle, coach and so forth) (Cargolux Airlines International, 2009, p.33).

In 2007, Cargolux Airlines International joined the United National Global Compact. As a signatory to the Compact, firms pledge to embrace, support, and enact a set of values in the areas of human rights, labor standards, anti-corruption, and the environment (Cargolux International Airlines, 2008). In signing up to the UN Global Compact, Cargolux pledged to apply 10 key principles of sound management from both the environmental and social perspectives (Cargolux Airlines International, 2009; 2019). In 2012, Cargolux became a gold contributor to the UN Global Compact Foundation (Cargolux Airlines International, 2015). Cargolux has embraced the 2030 Agenda and the company has pledged its support of the United Nation's 17 Sustainable Development Goals (Cargolux Airlines International, 2018).

Cargolux Airlines International is also a member and participant in the International Civil Aviation Organization (ICAO) "Carbon Offsetting and Reduction Scheme for International Aviation" (CORSIA) program (International Civil Aviation Organization, 2022). Effective from 2021 onwards, an increased share of the carbon emission growth in the international air transport industry will be subject to offsetting under the International Civil Aviation Organization (ICAO) "Carbon Offsetting and Reduction Scheme for International Aviation" (CORSIA) program (Kováčik et al., 2021; Maertens et al., 2019). Effective from 1 January 2021, all international flights will become subject to offsetting obligations under the CORSIA program (International Air Transport Association, 2022b)

Cargolux Airlines International is also fully compliant with the European Union "Emissions Trading System" (EU-ETS) reporting requirements (Cargolux Airlines International, 2019). In accordance with the EU-ETS Emissions Trading System, all member airlines are required to produce and submit a mandatory Emissions Monitoring Plan. This plan describes the fuel consumption monitoring and reporting process together with the method applied to calculate the related carbon dioxide (CO_2) emissions (Cargolux Airlines International, 2012).

Throughout its history, Cargolux has been awarded the "LEAN and GREEN" award, which was established by the Dutch Ministry for Infrastructure and Environment in 2008. This international award recognizes efforts made by a firm to reduce their carbon footprint (CO_2 emissions) in

aviation logistics' by at least 10 percent in a 5-year period (Cargolux Airlines International, 2018).

Cargolux Airlines International also continuously assesses the environmental commitment of its appointed ground handling agents throughout its route network (Cargolux International Airlines, 2015).

4.3 Cargolux Airlines International Aircraft Fuel Consumption

Cargolux Airlines International annual Jet A1 aircraft fuel consumption (tonnes) and the year-on-year change for the period 2012 to 2020 is presented in Figure 2. As can be observed in Figure 2, Cargolux's Jet A1 fuel consumption has principally exhibited an upward trend reflecting the growth in the airline's services, route network expansion, and the growth in the airline's aircraft fleet. This overall upward trend is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, more values are above the line than below. Figure 2 shows that there was a single year in the study period, when the airline's annual fuel consumption decreased on a year-on-year basis. This decrease occurred in 2018, when aircraft fuel consumption decreased by 0.62% on the 2017 levels. There were four spikes in Cargolux's aircraft jet fuel consumption during the study period. These increases were recorded in 2013 (+14.84%), 2014 (+11.04), 2015 (+9.44%), and 2017 (+9.94%) and reflected higher fuel usage requirements in those years (Figure 2).

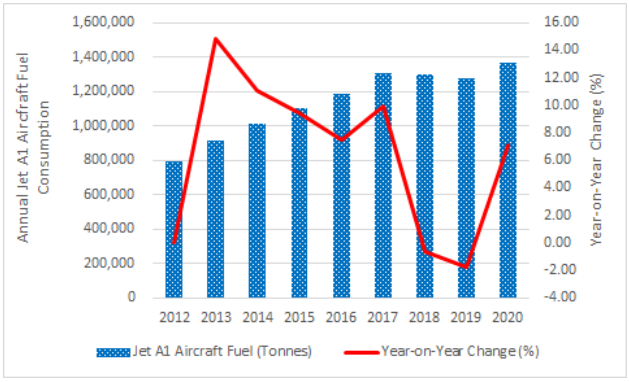

Fig.2: Cargolux Airlines International annual Jet A1 aircraft fuel consumption and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

4.4 Cargolux Airlines International Cooling Energy Consumption

Summer months can be very hot in Luxembourg with temperatures in July and August reaching around 30 degrees Celsius (86°F) (World Weather & Climate Information, 2022). Cargolux Airlines International annual cooling energy consumption (kWh) and the year-on-year change for the period 2012 to 2020 is depicted in Figure 3. As can be observed in Figure 3, Cargolux Airlines International annual cooling energy consumption (kWh) fluctuated throughout the study period reflecting differing cooling requirements. The lowest annual cooling consumption was recorded in 2017, when the airline consumed 426,900kWh of cooling energy (Figure 3). The highest annual cooling consumption was recorded in 2018, when the airline consumed 527,000 kWh of cooling energy (Figure 3). During the study period, there were several pronounced annual increases in this metric, with these spikes occurring in 2013 (+8.19%), 2016 (+9.06%), and 2018 (+23.44%), respectively (Figure 3). These increases reflected the necessity for higher levels of cooling energy in these years. Figure 3 shows that there were two quite significant annual decreases in Cargolux Airlines International annual cooling energy consumption during the study period. These decreases were recorded in 2017 (-11.74%), and 2019 (-8.53%) (Figure 3) and could be attributed to more favorable temperatures that resulted in lower cooling requirements for the airline in 2017 and 2019, respectively.

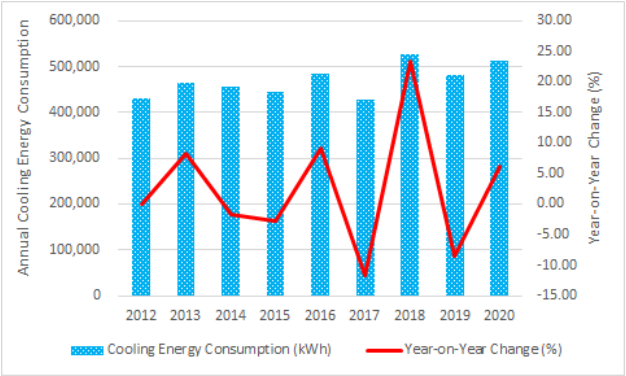

Fig.3: Cargolux Airlines International annual cooling energy consumption and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

4.5 Cargolux Airlines International Diesel Consumption

Cargolux Airlines International annual diesel consumption for its ground service equipment (GSE) and vehicles together with the year-on-year change for the period 2012 to 2020 is presented in Figure 4. Figure 4 shows that the airline's annual diesel consumption oscillated quite markedly during the study period. The lowest annual diesel consumption was recorded in 2014 (13,542 litres), whilst the highest annual diesel consumption was recorded in

2016 (20,851 litres) (Figure 4). As can be observed in Figure 4, there were quite pronounced increases in the airline's diesel consumption in 2015 (+11.67%), 2016 (+37.87%), and 2018 (+30.13%), with these increases reflecting greater ground service equipment (GSE) and vehicle usage patterns. Figure 4 also shows that there were several significant annual decreases in diesel consumption during the study period. These decreases occurred in 2014 (-22.40%), 2017 (-29.70%), and 2020 (-13.79), respectively (Figure 4) and could be attributed to lower ground service equipment (GSE) and vehicle usage patterns.

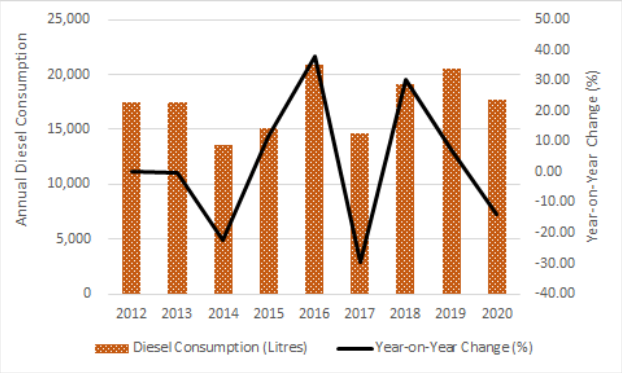

Fig.4: Cargolux Airlines International Airline annual diesel consumption and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

4.5 Cargolux Airlines International Electricity Consumption

Cargolux Airlines International annual electricity consumption (kWh) and the year-on-year change from 2012 to 2020 is presented in Figure 5. As can be observed in Figure 5, there were two discernible trends in the airline's electricity consumption during the study period. There was a general downward trend from 2012 to 2015, when the annual electricity consumption decreased from 5,844,467 kWh in 2012 to a low of 5,582,725 kWh in 2015. There was a general upward trend in the airline's electricity consumption from 2016 to 2020, when it increased from 5,787,954 kWh in 2016 to a high of 6,107,273 kWh in 2020 (Figure 5). This overall upward trend between 2016 and 2020 is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, more values are above the line than below. Figure 5 shows that there were three years in the study period when Cargolux's electricity consumption decreased on a year-on-year basis. These decreases occurred in 2013 (-1.08%), 2015 (-3.54%), and 2019 (-0.67%) and these decreases reflected lower electricity consumption patterns by Cargolux.

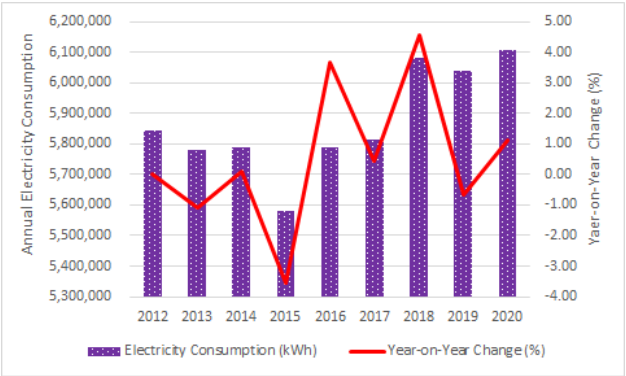

Fig.5: Cargolux Airlines International annual electricity consumption (kWh) and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

Figure 6 presents Cargolux Airlines International annual electricity consumption per workload unit (WLU) and the year-on-year change (%) for the period 2012 to 2020. One workload (WLU) is equivalent to 100 kilograms of air cargo handled (Doganis, 2005; Graham, 2005; Teodorović & Janić, 2017). As can be observed in Figure 6, Cargolux Airlines International annual electricity consumption per workload unit (WLU) has largely exhibited an overall downward trend throughout the study period. This downward trend is demonstrated by the year-on-year percentage change line graph, which is more negative than positive, that is, more values are below the line than above. The largest single annual decrease in this metric was recorded in 2013 when Cargolux Airlines International Airline annual electricity consumption per workload unit (WLU) decreased by 15.24% from a high of 0.905 kWh/WLU in 2012 to 0.767 kWh/WLU in 2013. Figure 6 also shows that there were two years in the study period when this metric increased on a year-on-year basis. These increases were recorded in 2018 (+5.87%) and 2019 (+3.63%) (Figure 6). The overall downward trend is very favorable given the increases in air cargo traffic handled, and fleet and network expansion throughout the study period.

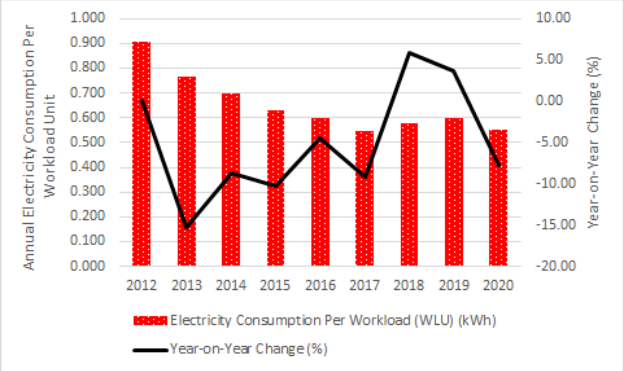

Fig.6: Cargolux Airlines International annual electricity consumption per workload unit (WLU) and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

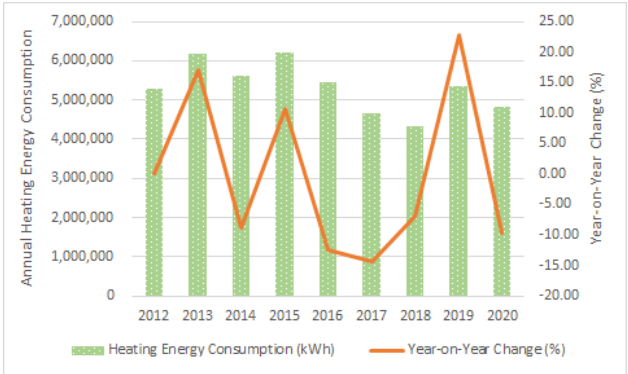

Fig.7: Cargolux Airlines International annual heating consumption and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

4.6 Cargolux Airlines International Heating Energy Consumption

Luxembourg has cold winters (Climates to Travel, 2022; Eccardt, 2005), and hence, there is a requirement by Cargolux Airlines International to heat its offices and facilities. Figure 7 presents Cargolux Airlines International annual heating consumption and the year-on-year change for the period 2012 to 2020. As can be observed in Figure 7, Cargolux Airlines International annual heating consumption has oscillated over the study period in line with the requirements to heat its facilities during the winter periods. Figure 7 shows that there were three quite pronounced spikes in this metric during the study period. The first spike occurred in 2013 when the airline's annual heating consumption increased by 17.09% on the 2012 levels. This was followed by the second spike in 2015 when the annual heating consumption increased by 10.66% on the 2014 levels. The most significant annual increase in this metric was recorded in 2019 when Cargolux annual heating consumption increased by 22.83% on the 2018 levels. Figure 7 shows that there were four quite significant decreases in Cargolux annual heating consumption during the study period. These decreases were recorded in 2014 (-8.89%), 2016 (-12.55%), 2017 (-14.28%), and 2020 (-9.69%) (Figure 7). These decreases may be attributed to the more favorable weather conditions that mitigated the airline's heating requirements.

4.7 Cargolux Airlines International Industrial Fuel Consumption

Cargolux Airlines International annual industrial fuel consumption and year-on-year change (%) from 2012-2020 is depicted in Figure 8. Figure 8 shows that the airline's annual industrial fuel consumption has largely displayed a general downward trend, decreasing from 85,633 litres in 2012 to a low of 56,469 litres in 2020. The general downward trend is demonstrated by the year-on-year percentage change line graph, which is more negative than positive, that is, more values are below the line than above. Figure 8 shows that there were four quite significant annual decreases in Cargolux Airlines International annual industrial fuel consumption throughout the study period. These decreases occurred in 2013 (-11.94%), 2016 (-19.26%), 2019 (-13.36%), and 2020 (-14.18), respectively (Figure 8). These decreases could be attributed to lower consumption patterns by the airline. Figure 8 shows that there were two quite significant annual increases in this metric during the study period. The most significant annual increase was recorded in 2015, when the airline's annual industrial fuel consumption increased by 28.91% on the 2014 levels. In 2015, Cargolux Airlines International consumed 91,926 litres of industrial fuel, which represented the largest single annual consumption of industrial fuel. Figure 8 also shows that there was a 9.24% increase in this metric in 2018, and once again this increase was the result of higher consumption patterns.

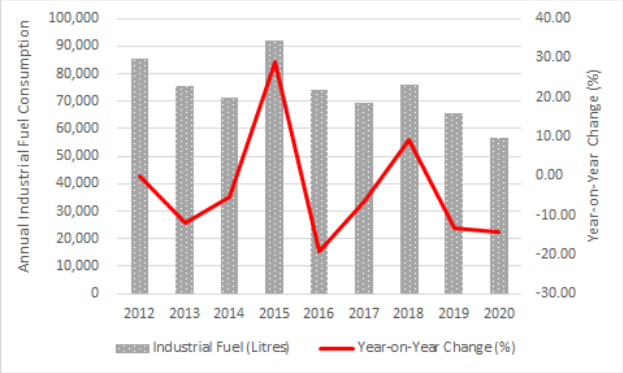

Fig.8: Cargolux Airlines International annual industrial fuel consumption and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

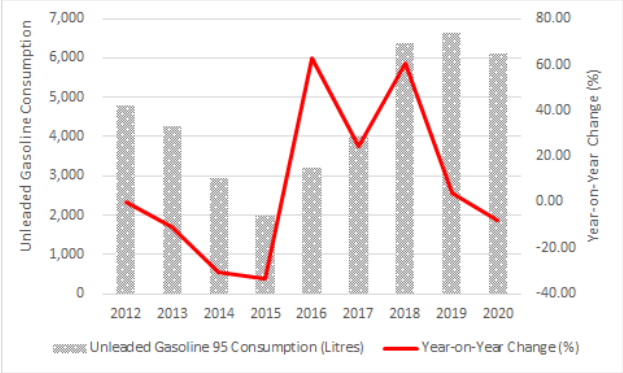

Fig.10: Cargolux Airlines International annual unleaded gasoline 95 consumption and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

4.8 Cargolux Airlines International Natural Gas Consumption

Cargolux Airlines International also purchases natural gas as part of their energy procurement strategy. Natural gas is a mixture of hydrocarbon gas (primarily composed of low molecular hydrocarbons) as well as a small number of non-hydrocarbon gases (Li & Yu, 2022). Figure 9 presents Cargolux Airlines International annual natural gas consumption and the associated year-on-year change for the period 2012 to 2020. As can be observed in Figure 9, Cargolux annual natural gas consumption has fluctuated throughout the study period reflecting differing consumption patterns. Figure 9 shows that there were three quite significant annual increases in the airline's natural gas consumption during the study period. These increases were recorded in 2013 (+9.52%), 2019 (+7.95%), and 2020 (+7.95%) (Figure 9) and were the result of natural gas requirements in these respective years.

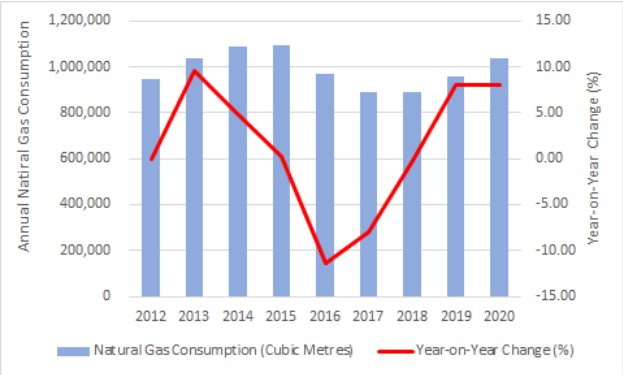

Fig.9: Cargolux Airlines International annual natural gas consumption and year-on-year change (%): 2012-2020.

Source: Data derived from Cargolux Airlines International (2012, 2016, 2019, 2021c)

4.9 Cargolux Airlines International Unleaded Gasoline 95 Consumption

To support its operations, Cargolux Airlines International operates a fleet of ground service vehicles which are powered by unleaded 95 gasoline. Cargolux Airlines International annual unleaded gasoline 95 consumption and year-on-year change from 2012 to 2020 are depicted in Figure 10. Figure 10 shows that there were two discernible trends in Cargolux annual unleaded 95 gasoline consumption during the study period. Cargolux annual 95 gasoline consumption displayed a general downward trend from 2012 to 2015, decreasing from 4,785 litres in 2012 to a low of 1,970 litres in 2015. This downward trend is demonstrated by the year-on-year percentage change line graph, which is more negative than positive, that is, all the values are below the line. Figure 10 shows that there were two quite significant decreases in this metric during this period. These decreases occurred in 2013 (-10.84%), and 2014 (-30.87%) (Figure 10) and were in line with lower vehicle fuel requirements. Figure 10 shows that there was a general upward trend in the airline's unleaded 95 gasoline consumption during the period 2015 to 2020, when it increased from 1,970 litres in 2015 to 6,125 litres in 2020. This overall upward trend is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, more values are above the line than below. Figure 10 shows that there were three pronounced increases in this metric during the period 2015 to 2020. These significant increases were recorded in 2016 (+62.94%), 2017 (+24.12%), and 2018 (+60.46%), respectively, and were the result of higher vehicle fuel consumption (Figure 10). Figure 10 shows that there was a very significant annual decrease in this metric in 2015, when it decreased by 33.19% on the 2014 levels. There

was a smaller decrease in the airline's annual unleaded 95 gasoline consumption in 2020, when it decreased by 7.74% on the 2019 levels. Once again, this decrease reflected lower ground service vehicles fuel requirements in 2020.

4.10 Cargolux Airlines International Energy Consumption Mitigation Measures

4.10.1. Aircraft Fleet Renewal

The most significant reductions in Cargolux Airlines International energy consumption have been achieved through the airline's fleet renewal program. As previously noted, Cargolux was the launch customer for the next generation Boeing 747-8F freighter aircraft. Cargolux had ordered 13 of these aircraft and held options to purchase two more. Cargolux was the first airline to operate this aircraft type. The 13 aircraft were scheduled to be delivered in 2014 (Cargolux Airlines International, 2009). Cargolux commenced a fleet rollover program in 2011 that entailed the introduction of the Boeing 747-8 freighter, which is the most fuel efficient and environmentally friendly aircraft in its class. The new Boeing 747-8 freighter aircraft would gradually replace Cargolux's 747-400 freighter fleet (Cargolux Airlines International, 2015). In 2016, Cargolux concluded its fleet rollover program following the delivery of its 14th and final Boeing 747-8 freighter aircraft entering its fleet (Cargolux Airlines International, 2017b).

4.10.2 Cargolux – SkyCell Partnership

Cargolux Airlines International has partnered with the Swiss company SkyCell to offer Cargolux's pharmaceutical shippers' temperature-controlled container solutions. The "SkyCell" aircraft containers offer a lower tare weight, thereby reducing fuel consumption (Cargolux Airlines International, 2018).

4.10.3 Continuous Descent Operation (CDO): Fuel Saving Reduction Initiative

In 2018, Cargolux Airlines International participated in the inaugural meeting to establish "continuous descent operations (CDO) at Luxembourg Airport Cargolux subsequently cooperated with the local air navigation service provider (ANSP) to develop CDOs arrivals into Luxembourg (Cargolux Airlines International, 2019). A continuous descent operation (CDO) is one in which the arriving aircraft descends from its cruise level to an airport with its engines at near-idle thrust (Itoh & Uejima, 2013). With the Cargolux CDO program a number of waypoints on the flight route were established that enable pilots to efficiently plan the descent of their aircraft. Both CDOs and CDAs (Continuous Descent Operations and Approach) methodologies offer the potential for significant fuel savings. For example, a CDO(F) arrival can provide fuel savings of approximately 250 kg per flight for a Boeing B747 freighter aircraft, as the engines remain at a near-idle thrust during the process (Cargolux Airlines International, 2019).

4.10.4 Engine Compressor Washing

In 2007 and 2008, research undertaken by Cargolux's Engineering Department found that certain aircraft engine types consume less fuel if the engine core is regularly washed and cleaned. This cleaning removes the deposits that have accumulated over time on the compressor blade airfoils. The washing of the engine core also improves air flow and overall engine performance. Cargolux have noted that washed General Electric engines consume 0.18% less fuel. The same procedure applied to Rolls Royce engines did not provide substantial fuel savings. In 2008, Cargolux began to regularly clean both General Electric and Rolls Royce engines. Based on the company's aircraft fuel consumption and the General Electric fleet composition, annual savings of around 500 tonnes of fuel per year were achieved (Cargolux Airlines International, 2009, p. 31).

The "Core Engine Compressor" wash was perfected by Cargolux in 2018. This cleaning process is performed on the airline's GENX-2B, CF6-80C2B5F, and selected RB211-524H2-T engines (Cargolux International Airlines, 2019). Like earlier initiatives, this practice is a further fuel-saving measure.

4.10.5 Environmentally Friendly Beam Solution

In 2017, Cargolux Airlines International ratified an agreement with Trinkaus-Solutions (Germany) for the use of the company's "squAIR" -timber product. With a tare weight of only 1.2 kilograms per metre, the beam is 80% lighter than conventional wood, and thus, lowers fuel consumption. Cargolux has estimated that its use of the "squAIR"-timber product potentially reduces its fuel consumption by approximately 1,200 tonnes per year (Cargolux Airlines International, 2018).

4.10.6 Fuel Consumption Reduction Initiative

Cargolux Airlines International has established a "Fuel Efficiency Round Table" initiative. In 2016, Cargolux's fuel-saving initiative saved 2,031 tons of fuel from its flight operations (Cargolux Airlines International, 2017a).

4.10.7 Future Air Navigation System (FANS) Operations

In 2010, Cargolux Airlines International completed a program to equip all aircraft in its own aircraft fleet with the Iridium onboard satellite communications system. The Iridium system offers global coverage, including over the polar regions. Hence, in June 2010, Cargolux aircraft were able to operate on "Future Air Navigation System"

(FANS) routes and thereby achieve significant savings in flying time (Cargolux Airlines International, 2011). The "Future Air Navigation System" (FANS) is an operational concept which relies upon satellite-based navigation and communication to provide the improvements required in communication, navigation, and surveillance (CNS) to efficiently handle the projected increase in traffic levels (Golmohammad & Mehdizadeh Dastjerdi, 2012).

At the time of the introduction of this new service, the most important FANS route throughout the Cargolux network was located over the Gobi Desert between Almaty and Hong Kong. In 2010, this route was served on four to six flights per week. The fuel savings were very significant as flight time is reduced by 30 to 35 minutes on each flight. The fuel savings that could be achieved are estimated at 700 tonnes per year. Cargolux aims to extend FANS flights throughout its worldwide network, wherever air routes can support this system and offer a shorter alternative routing (Cargolux International Airlines, 2011).

4.10.8 Performance Improvement Package (PIP)

Cargolux International Airlines has implemented a retrofit program for the airline's GEnx engines from the early Boeing 747-8Fs that had entered the airline's fleet. This initiative improves both the efficiency and life of the engine, but also has a positive impact on fuel consumption (Cargolux Airlines International, 2018).

4.10.9 Reduction in Aircraft Weight

In 2008, a weight reduction program was undertaken for the entire Cargolux International Airlines aircraft fleet. Around 250kg of material was removed from each aircraft through a modification of the aircraft's bulk hold compartment, the removal of unused cargo locks, and through a modification of the airline's "fly-away maintenance kit (Cargolux International Airlines, 2009).

4.10.10 The Use of Fixed Electrical Ground Power Systems

A number of handling activities are performed at airports. The activities associated directly with the aircraft itself include the provision of power, cleaning, loading or unloading of baggage/air cargo (Doganis, 2005), lavatory services, aircraft marshalling, aircraft towing or pushback, and aircraft fueling (Ashford et al. 2013; Kazda & Caves, 2015; Thompson, 2007). Consequently, electrical power is required on the airport apron for the servicing of aircraft prior to engine start-up. External electrical power is also often used for aircraft engine start-up (Ashford et al. 2013). The auxiliary power unit (APU) is a small gas size turbine engine or small powerplant located near the belly of an aircraft (Anvekar, 2016). APU's are units that supply the essential requirements of the aircraft whilst it is on the ground at the airport and without the main engines operating, or when no external power source is available (Smith, 2004). These essential services include electricity, compressed air, and air-conditioning (Filippone, 2012). In 2007, Cargolux launched a network wide campaign to ensure that, wherever possible, electric ground power was obtained from the airport, from either a diesel-powered ground power unit (GPU), or from a fixed electrical ground power unit (FEGP). Ground power is far more fuel efficient (Cargolux International Airlines, 2009). Consequently, a ground power unit is used to supply electricity to the aircraft wherever possible (Cargolux International Airlines, 2018).

4.10.11 The Use of Sustainable Aviation Fuels

A very important development in the air transport industry in recent trends has been the growing trend by airports and airlines to use aviation biofuel as a key environment sustainability measure (Baxter et al., 2020). The move towards the use of sustainable aviation fuels has been driven by the growing concerns on climate change and energy supply by the industry (Brooks et al., 2016). Consequently, alternative jet fuel (AJF) technologies have gained strong interest (Staples et al., 2014). Aviation biofuels are therefore becoming an important substitute for fossil fuel in the Cargolux Airlines International Cargolux was one of the founding members of the "Sustainable Aviation Fuel Users Group" (SAFUG). This body is a cross industry initiative whose objective is to promote and bring to market sustainable aviation biofuels (Cargolux Airlines International, 2019). The Sustainable Aviation Fuel User's Group (SAFUG) brings together airlines and other stakeholders all of whom have a common interest in developing a long-term, renewable source of aviation fuel. An important objective of this group is that proposed aviation biofuels does not compete with agricultural food production, does not pose a threat to fragile eco-systems, and also provides a positive socio-economic impact (Cargolux Airlines International, 2011).

On 25 October 2021, Cargolux announced the launch of its sustainable aviation fuel (SAF) program. A key aim of this policy was to reduce carbon dioxide (CO_2) emissions and provides the foundation for a customer sustainability program, that will offer more sustainable options for the airline's customers transportation requirements (Cargolux Airlines International, 2021b; Turner, 2021).

4.10.12 Three Engine Taxing to Aircraft Parking Position

Cargolux Airlines International has implemented a procedure whereby aircraft shut down one of four engines during the taxi to the parking position on the ramp (Cargolux International Airlines, 2018).

V. CONCLUSION

Based on a qualitative longitudinal research design this study has examined how Cargolux Airlines International, a major global air cargo carrying airline, manages its aircraft fuel and ground-based facility energy consumption. The study covered the period 2012 to 2020.

Cargolux Airlines International procures eight different types of energy to support its operations. The energy sources are cooling energy, diesel, electricity, heating energy, industrial fuel, jet A1 aircraft fuel, natural gas, and unleaded gasoline 95. The most significant energy source is the jet A1 aircraft fuel used to power its flights around the world. The second most significant energy source is the electricity used to power its ground-based facilities. A further key energy source is natural gas.

The case study revealed that Cargolux's Jet A1 fuel consumption has principally exhibited an upward trend reflecting the growth in the airline's services, route network expansion, and the growth in the aircraft fleet during the study period. Cargolux International Airlines annual Jet A1 fuel increased from a low of 792,719 tonnes in 2012 to a high of 1,367,937 tonnes in 2020.

Cargolux Airlines International annual cooling energy consumption (kWh) oscillated over the study period reflecting differing cooling requirements. The lowest annual cooling consumption was recorded in 2017, when the airline consumed 426,900kWh of cooling energy. During the study period, the airline's highest annual cooling consumption was recorded in 2018, when the airline consumed 527,000 kWh of cooling energy

Cargolux Airlines International annual diesel consumption fluctuated quite markedly during the study period reflecting differing vehicle fuel consumption requirements and usage. The lowest annual diesel consumption was recorded in 2014 (13,542 litres), whilst the highest annual diesel consumption was recorded in 2016 (20,851 litres).

The case study found that there was a general downward trend in Cargolux Airlines International annual electricity consumption during the period 2012 to 2015, when the annual electricity consumption decreased from 5,844,467 kWh in 2012 to a low of 5,582,725 kWh in 2015. There was a general upward trend in the airline's electricity consumption from 2016 to 2020, when it increased from 5,787,954 kWh in 2016 to a high of 6,107,273 kWh in 2020. Cargolux Airlines International annual electricity consumption per workload unit (WLU) has also largely exhibited an overall downward trend over the period 2012 to 2020.

Cargolux Airlines International annual heating consumption also oscillated over the study period in line with the requirements by the airline to heat its facilities during the winter periods. The lowest annual heating consumption was recorded in 2018 (4,346,000 kWh), whilst the highest annual heating consumption was recorded in 2015 (6,227,000 kWh).

Cargolux Airlines International annual industrial fuel consumption primarily displayed a general downward trend, decreasing from 85,633 litres in 2012 to a low of 56,469 litres in 2020, reflecting lower industrial fuel usage patterns.

Cargolux Airlines International annual natural gas consumption has fluctuated throughout the study period reflecting differing consumption patterns at the airline. The lowest annual natural gas consumption was recorded in 2018 (887,631 cubic metres), whilst the highest annual natural gas consumption was recorded in 2015, when the airline consumed 1,090,762 cubic metres of natural gas.

Cargolux Airlines International annual 95 gasoline consumption displayed a general downward trend from 2012 to 2015, decreasing from 4,785 litres in 2012 to a low of 1,970 litres in 2015. There was a general upward trend in the airline's unleaded 95 gasoline consumption during the period 2015 to 2020, when it increased from 1,970 litres in 2015 to 6,125 litres in 2020. The highest annual gasoline 95 consumption occurred in 2019, when the airline consumed 6,639 litres of gasoline 95.

Throughout the study period from 2012 to 2020, Cargolux Airlines International implemented a range of energy savings measures that enabled the airline to optimize its energy consumption, whilst at the same time mitigating its impact on the environment. A major energy saving measure has been the modernization of its aircraft fleet. Cargolux concluded its Boeing 747-8 freighter aircraft fleet rollover plan in 2016. The case study showed that Cargolux Airlines International has been able to optimize its jet fuel consumption through enhanced air traffic control management measures. These measures include the continuous descent operation (CDO) at Luxembourg Airport and the implementation of the future air navigation system, with this system providing significant savings in aircraft flying times. Other energy saving measures implemented by Cargolux include the General Electric powered aircraft engine performance improvement package, aircraft engine compressor washing, the reduction in the weight of its aircraft fleet, the use of fixed electrical ground power (FEGP), the use of lighter weight "SkyCell" aircraft containers, the use of sustainable aviation fuel, and the use of three engines when aircraft are taxiing to their parking stand.

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A Review on Flow Injection Analysis for Indirect Determination of Cyanide ion in Environment by Flame Atomic Absorption Spectrometer

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Abstract— *Among inorganic anions, cyanide is a potent toxicant in environment. Its species are historically known as the most harmful chemical pollutants of the environment to directly affect human health and some aquatics activity, even at minimum levels. Cyanide compounds are widely available with various chemical compositions and are applied in many industrial fields. This mini-review focused on the cyanide species and their measurement utilizing several analytical techniques. Detailed information on an indirectly determined cyanide species in various environmental samples was also reviewed using a flame atomic absorption spectrometer equipped with a flow injection system (FIA-FAAS). Obtained various analytical performance properties of an indirectly measured free cyanide ion in various samples using FAAS investigated from this study.*

Keywords— ***Nonmetals, Cyanide ion, Indirect determination, FIA-FAAS.***

I. INTRODUCTION

Cyanide compounds denote any chemical compounds that have carbon and nitrogen atoms as a (C≡N) triple bonded or including (CN^-) functional group (Newhouse & Chiu, 2010). Cyanide is categorically introduced as the most harmful compounds on earth, posing a severe health hazard and direct toxic effects on humans and, more so to aquatic life even at low levels. Among inorganic anions, cyanide is a potent toxicant and one of the most harmful chemical pollutants of the environment historically known to be used as a chemical weapon (Ogbuagu, Airaodion, Okoroukwu, Ogbuagu, & Ekenjoku, 2019). This mini-review focused on the cyanide species, uses, and side effects. Several analytical techniques were mentioned to quantify cyanide species in environment. Detailed information on cyanide species' via indirect measurement in various real samples was also reviewed utilizing a flame atomic absorption spectrometer (FAAS).

1.1. Cyanide Species and their Uses

Cyanide compounds are available with various chemical compositions, physical and chemical properties (**Table 1**) (Newhouse & Chiu, 2010; Simeonova, Fishbein, & Organization, 2004). Hydrogen cyanide (HCN), potassium cyanide (KCN), and sodium cyanide (NaCN) are the most common cyanide compounds widely used in many fields (Newhouse & Chiu, 2010). Detailed information on several cyanide compounds is shown in **Table 1**. Historically, cyanide salts or agents which can form a cyanide gas when mixed with acids are lethal chemicals and broadly utilized in many industrial applications. The commonly applied cyanide species fields involve electroplating, metallurgy, chemical synthesis, agriculture, printing, tanning, photography, manufacturing of paper, and insecticides (Dobbs, 2009). Cyanide, a nitrile, is also applied in numerous industries, such as plastics, paints, mining, jewelry, pharmaceuticals, dyes, coal coking, and food processing (Sharma, Akhter, & Chatterjee, 2019).

Table 1: shows several chemical and physical properties of selected common cyanide compounds (Newhouse & Chiu, 2010; Simeonova et al., 2004).

Cyanide compounds	CASRN	Synonyms	Formula (M.wt.) g/mole	Form	Density (g/mL)	MP (°C)	BP (°C)	Solubility
Hydrogen cyanide	74-90-8	Hydrocyanic acid, Cyclone B, prussic acid	HCN (27)	Colorless gas or liquid	0.6884	-13.4	25.7	Ether, Ethanol
Potassium cyanide	151-50-8	Hydrocyanic acid, potassium salt	KCN (65)	White crystals or lumps	1.52	634.5	1,625	Water, ethanol
Sodium cyanide	143-33-9	Cyanogran, Cyanobrik, Cymag, white cyanide	NaCN (49)	White (powder) crystalline	1.6	563.7	1,496	Water, ethanol
Calcium cyanide	592-01-8	Calcyanide, cyanogas, calcyan, black cyanide	$Ca(CN)_2$ (92)	White powder	1.85	640	NA	Water, ethanol, weak acid
Cyanogen	460-19-5	Dicyanogen, ethanedinitrile, oxalonitrile	$(CN)_2$ (52)	Colorless gas	0.9537	-27.9	-21.17	Water, ethanol
Potassium silver cyanide	506-61-6	Potassium dicyanoargentate	$AgK(CN)_2$ (199)	White crystals	2.36	NF	NF	Water, ethanol
Copper cyanide	54-92-3	Cupricin	CuCN 89.56	Off-white powder	2.92	474	NF	Insoluble in water
Cyanogen chloride	506-77-4	Chlorine cyanide	CNCl 61.47	Colorless gas	1.19	−6.55	13.8	Water & alcohol

CASRN; CAS Registry Number, BP; boiling point, MP; melting point, M.wt.; molecular weight, NA; not found, NA; not applicable

1.2. Health Hazards

Exposure to cyanides leads to severe health hazards ongoing to their empathy to metals in the presented medium. Thus, cellular respiration malfunction symptoms by inhibition of cytochrome c oxidase will occur by cyanides side effects. As a result, their compound causes convulsions, increased blood acidity (acidosis), histotoxic hypoxia, loss of consciousness, and decline in the human central nervous system's myocardial activity and functioning of the human central nervous system (Ogbuagu et al., 2019). Cyanide poisoning happens when humans or any living organisms are directly exposed to cyanide species/ions in various ways. Exposed ways can be through drinking, industrial exposure, suicidal ingestion, long-term consumption of foods containing cyanide forms, and rarely smoke inhalation (Ogbuagu et al., 2019). For these reasons, many physicochemical processes have been developed and applied to remove cyanide species from aqueous wastes from the environment. Among them includes oxidation by hydrogen peroxide, microbial cyanide degradation, ozonization, and alkaline chlorination methods (Sharma et al., 2019).

II. ANALYTICAL TECHNIQUES

Several analytical methods and techniques have been widely applied to determine cyanide species directly or indirectly in various environmental samples (Ma & Dasgupta, 2010). Among these includes spectrophotometry and colorimetry(Hao et al., 2014; Osobamiro, 2012), spectrofluorimetry(Chueachot & Chanthai, 2014; Long et al., 2019), indirect flame atomic absorption spectrometry (FAAS) (Dadfarnia, Shabani, Tamadon, & Rezaei, 2007), micro-chemiluminescence(Amjadi, Hassanzadeh, &Manzoori, 2014), room temperature phosphorimetry(Fernández-Argüelles, Costa-Fernández, Pereiro, & Sanz-Medel, 2003), gravimetric, and complexometric titrations (Breuer, Sutcliffe, & Meakin, 2011). Chromatographic techniques such as high-performance liquid chromatographic-mass spectrometry (Tracqui, Raul, Geraut, Berthelon, & Ludes, 2002), ion chromatography (Cengiz, Durak, Nilufer, & Bilgin, 2015), and gas chromatography (Sadeg & Belhadj-Tahar, 2009) have also been applied to analyze cyanide species. Many electrochemical techniques were also applied to quantify cyanide components including, voltammetry (Sousa, Godinho, & Aleixo, 1995), amperometry(Jaszczak, Ruman, Narkowicz, Namieśnik, & Polkowska, 2017), potentiometry(Amayreh & Abulkibash, 2017), and capillary electrophoresis (Jermak, Pranaitytė, & Padarauskas, 2006).

2.1 Flame Atomic Absorption Spectrometry (FAAS)

FAAS is well-known as powerful analytical techniques were broadly utilized for metal analysis. This technique is commonly applied in many science fields due to its modest setup, robustness, low costs, and suitable selectivity. Metals and metalloids can be directly quantified utilizing the AAS technique, whereas it is impossible to determine nonmetals with this technique directly. Nonmetals are difficult to directly measured by AAS due to their positioned resonance lines in the vacuum-UV range (Akman, Welz, Ozbek, & Pereira, 2015). However, nonmetals and their components (**Table 2**) can be indirectly measured and quantified in various samples utilizing their diatomic or complex molecular absorption (Akman et al., 2015; Jaszczak et al., 2017; Noroozifar, Khorasani-Motlagh, & Taheri, 2009; Yebra & Cespon, 2000).

Table 2: shows the permissible limit (mg/L) of some common non-metallic ions/compounds announced by EPA that can be quantified indirectly by FAAS.

Non-metal Ions/ Compounds	**Permissible Limits (mg/L) US EPA (EPA, 2004)**	**Documented Studies Using Indirect FAAS Technique**
Cyanide (CN^-)	0.2	(Dadfarnia et al., 2007)
Chloride (Cl^-)	250	(Jimenez, Gallego, & Valcárcel, 1987)
Iodide (I^-)	0.018	(Yebra & Cespon, 2000)
Fluoride (F^-)	2.0	(Akman et al., 2015)
Sulfide ($SO_3^=$)	2.0	(Zare-Dorabei, Boroun, & Noroozifar, 2018)
Nitrite (NO_2^-)	1	(Noroozifar, Khorasani-Motlagh, Taheri, & Homayoonfard, 2007)
Nitrate (NO_3^-)	10	(Meissam Noroozifar et al., 2007)
Sulphate ($SO_4^=$)	250	(Kapitány, Nagy, Posta, & Béni, 2020)
Phosphate ($PO_4^=$)	0.04	(Tekula-Buxbaum, 1981)
Silicate (SiO_4^{4-})	-	(Kirkbright, Smith, & West, 1967)

2.2 Flow Injection Analysis (FIA)

Flow injection analysis (FIA) methods are more popular, engaging, and applicable routine analysis systems in various fields of environment applications (Hansen & Miró, 2007). This system provides various exciting points, including ease of applicability, flexibility, reproducibility, accessibility, simplicity, an increasing sampling rate, decreasing human participation, reducing the volume of chemical consumption (samples and reagent), reduced time-wasting, and preventing lab contamination (GHOUS, 2011; Hansen & Miró, 2007). The combination of solid-phase reagents/reactors (SPR) in FIA manifolds also provided several advantages and improved this system's performances (Gomez & Calatayud, 1998; Noroozifar, Khorasani-Motlagh, Taheri, & Zare-Dorabei, 2008). The utilization of the FIA-FAAS

system equipped with SPRs has been recognized and widely applied to be an effective method for automation, preparing, and analyzing various samples (Gomez & Calatayud, 1998; Kapitány et al., 2020; Noroozifar et al., 2009). This coupled instrument was well applied to enhance sensitivity and selectivity during nonmetal ions or compounds analysis. The assessment of several inorganic and organic compounds has been easily improved, utilizing SPR with FIA system. Many studies documented the application of SPRs in the FIA-FAAS system for the indirect quantification of nonmetal ions or compounds in various environmental samples (Gomez & Calatayud, 1998; Hansen & Miró, 2007; Jimenez et al., 1987; Noroozifar, Khorasani-Motlagh, & Hosseini, 2006; Zare-Dorabei et al., 2018).

III. LITERATURE REVIEW

Free cyanide and its species quantification applying FAAS was also impossible. FAAS is a powerful technique indirectly adopted to quantify cyanide species in various environment samples (Dadfarnia et al., 2007; Gürkan & Yılmaz, 2013a; Noroozifar et al., 2009). FIA equipped with the FAAS technique was a highly successful applied method to analyze free cyanide ion indirectly. This review also focused on the indirect assessment and measurement of free cyanide in many samples. Cyanide presented as a free ion, or total cyanide species were determined in many samples such as fish, cocoyam, cassava, well and dam water (Kwaansa-Ansah, Amenorfe, Armah, & Opoku, 2017), pharmaceuticals (Gomez & Calatayud, 1998), river and sea waters (Fullana-Barcedó, Bosch-Serrat, Marin-Saez, & Mauri-Aucejo, 1995), and industrial wastewaters (Noroozifar, Khorasani-Motlagh, & Hosseini, 2005). Many studies have been documented concerning the indirect analysis and quantification of cyanide species using FAAS. Detailed analytical performance properties on the indirectly used measurement of free cyanide ion by FIA-FAAS in the last and this century are shown in **Tables 3** and **4**, respectively.

For the first time, Manahan and Kunkel (1973) proposed a simple and effective AAS procedure for indirect quantification of CN^- ion based upon the solubility degree of copper carbonate ($CuCO_3$) in the sample solution and on the determination of the amount of copper attended to form a cyanide-copper complex ($Cu(CN)_3^-$) in the basic medium. They applied the proposed method to quantify low levels of cyanide at the time using the FIA system. The spiked sample was also investigated to show the quantitative recovery of cyanide (Manahan & Kunkel, 1973).

After that, Haj-Hussein, Christian, and Ruzicka (1986) proposed a novel FIA system for the indirect quantification of free CN^- ions in aqueous systems using the AAS technique. A microcolumn, which included cupric sulfide (CuS) packed column, was proposed in the on-line FIA-AAS system procedure. During analysis, aqueous cyanide solutions were inserted through an on-line CuS packed column at a pH of 11. Simultaneously, potassium hydroxide solution with a pH of 11 was utilized and passed into the system as a carrier stream. As a result, the analyte produced the cuprocyanide complex, presented in the eluent solution, and then measured by the FAAS detector. The consequences of sample volume, flow rate of the sample or used reagents and various anionic interferences during the process were examined.Various factors, such as carrier solution, injection volume, flow rate, filter selection, and AAS parameters, were investigated to optimize the flow system and obtain reproducible results. The recorded data confirmed that the sensitivity, range of linearity, and peak high could be significantly affected by the injection volume. In comparison with other methods, the selectivity, sensitivity, applicability, and detection technique applied were introduced as the novelty of the present method. **Figures 1** and **2** illustrate detailed components of the proposed microcolumn design and filter related to the on-line FIA-FAAS system (Haj-Hussein et al., 1986).

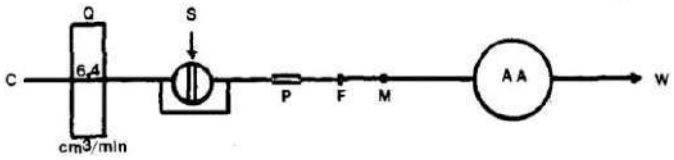

Fig.1: Illustrate the schematic diagram of FI manifold associated to FIA-AAS assessment of free CN^-, C, carrier; Q, flow rate (cm^3/min); S, point of injection; P, packed column; F, filter; M, the connection point to the nebulizer; AA, detector; W, waste (Haj-Hussein et al., 1986).

A new, sensitive, and high-speed method for extraction (**Table 3**) and indirect quantification of CN^-ion in various industrial samples by FAAS was also described in detail. This method was proposed based on the stable producing complex of CN^- ion in an alkaline medium Chattaraj and Das (1991). In the proposed method, a stable complex species of cyanide as a [Cu(BPTC)(CN)] formed in an alkaline medium (at pH 8.2) resulting from the occurring reaction by free CN^- in the sample solution with 2-benzoylpyridine thiosemicarbazone (BPTC). A mixture of isobutyl methyl ketone (IBMK) and isopentyl alcohol

with different ratios (7 + 1) was used as an appropriate organic phase for extracting the stable formed complex. The analyte, which is free cyanide, converted to the stable complex [Cu(BPTC)(CN)], extracted with high efficiency, can be quantified indirectly by FAAS (Chattaraj & Das, 1991).

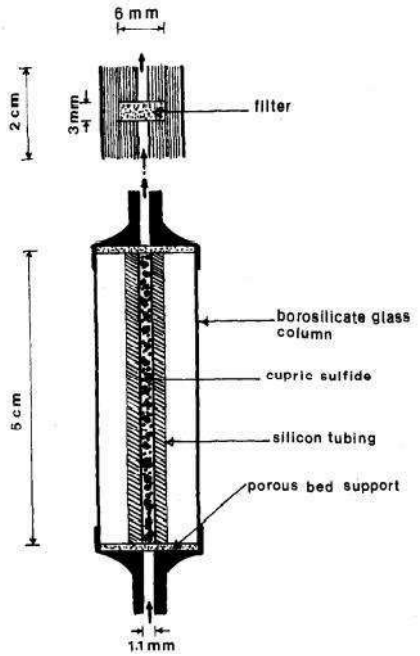

Fig.2: Shows the main components of the proposed microcolumn and filter related to the on-line FIA-FAAS structure (Haj-Hussein et al., 1986)

Esmadi, Kharoaf, and Attiyat (1993)also described and applied a new, simple, and potential FI-AAS method to determine cyanide and thiocyanate anions indirectly in aqueous systems. At first, the silver nitrate solution used as a precipitating agent passed through the flow system and precipitated the cyanide ion (analyte) in the sample solution in a Tygon tube coupled to the AAS detector. Deionized water was then used to wash the formed precipitate in the tube of the precipitating loop. Finally, NH_3 and $N_2S_2O_3$ solutions, which were used as dissolving agents, passed individually through the produced precipitated in the Tygon tube for a short period, dissolves the formed precipitate, and transfers it as a free cation content to the nebulizer of the detector. As a result, the formed cation concentration (silver ion), which is proportionally associated with the presented quantity of the examined analyte in the sample, could be measured using the AAS detector. The optimum condition was obtained due to investigate different parameters, including the concentration of the used reagents, various precipitating agents, washing time, and flow rate of the chemical solutions. Compared with other previously published methods, this method was introduced as a preferable procedure to determine cyanide ion in wastewater due to its simplicity, sensitivity, high precision, and not requiring the precipitating loop change. **Figure 3** illustrates the main components of the applied FI system in the proposed study (Esmadi et al., 1993).

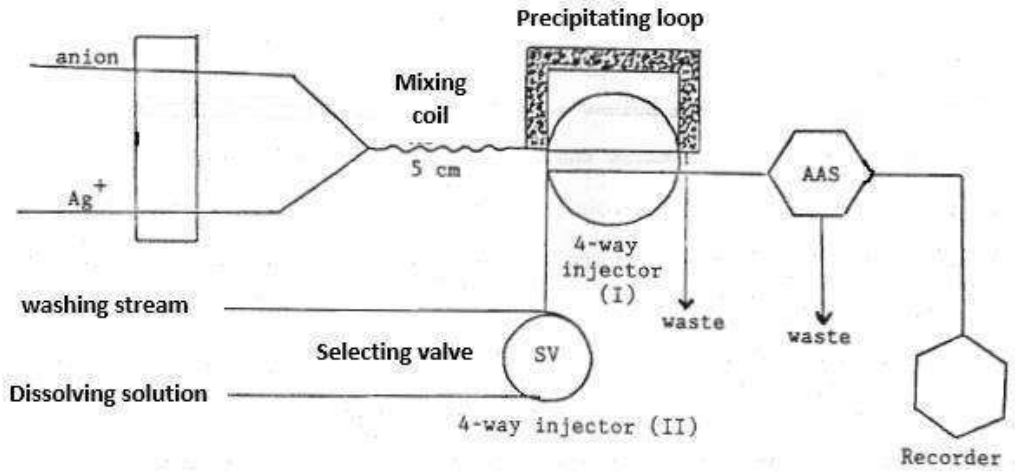

Fig.3: illustrates the principal components (schematic) of the utilized FI system to determine such as SCN^- and CN^- anions in aqueous systems (Esmadi et al., 1993).

In another study,Fullana-Barcedó et al. (1995) proposed two new, fast, and simple methods for the extraction (**Table 3**) and indirect assessment of free CN^- ion in water samples via AAS techniques. They suggested this procedure to produce a novel ion association compound of cyanide and then extraction to a new phase. The metal complexion of $Cu(CN)_3^{2-}$ or $Ag(CN)_2^-$ produced in the presence of metal ions (like Cu or Ag ion) into CN^-ion (at pH 10 or 11) in the sample solution, respectively. A new ion association compound $[C_{25}H_{46}N^+]_2[Cu(CN)_3^{2-}]$ or

$[C_{25}H_{46}N^+][Ag(CN)_2^-]$ formed from the reaction between the metal complexion with a quaternary ammonium ion (benzyldimethylhexadecylammonium ion, Cetalkonium chloride). Isomethylbutylketone (IBMK) solvent is then used as an organic phase to extract the produced ion association compounds. The AAS was used to measure the cyanide ion indirectly in the final association compound (Fullana-Barcedó et al., 1995).

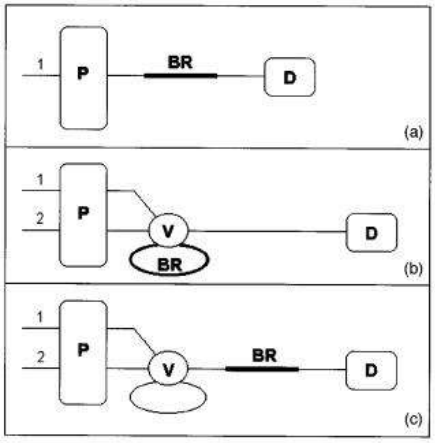

Fig.4: illustrates flow system construction: (a) preliminary experiments; (b) FIA system with the used SPR (BR) located in the loop system; and (c) suggested FIA system equipped to BR after injector part. 1, Sample; 2, carrier

In the last century, Gomez and Calatayud (1998)also suggested a new FIA procedure for indirect assessment of free cyanide in various pharmaceutical and environmental samples using FAAS. A new solid-phase reactor (SPR) filled with a homogenized mixture of immobilized silver iodide packed in polymeric resin beads was utilized during this investigation. The sample was firstly forced into a distilled water carrier, then passed throughout the proposed rector. Thus, silver cyanide complexes were produced from the direct reaction between the free silver ion in the reactor with the cyanide ion in the injected sample were finally determined by FAAS. The results verified that a good linear range (LR; 0.2 - 6.0 mg/L) was obtained. The method was successfully utilized to quantify free cyanide in different commercial samples, including industrial electrolytic baths and pharmaceutical products. This method was also preferred as a new, simple, selective, and more straightforward than other previously applied FIA methods in the literature survey. **Figure 4** illustrates the stepwise construction of the applied flow systems procedure.

stream solution; P, pump; V, valves for the sample injection; BR, solid-phase reactor; and D, FAAS as a detector (Gomez & Calatayud, 1998).

In this century, Noroozifar et al. (2005) developed and alsoapplied a novel FI system to determine free CN^- ion in industrial wastewaters using FAAS indirectly. A novel solid-phase reactor (packed column) prepared from homogenized and immobilized cadmium carbonate ($CdCO_3$) suspended on silica gel beads was proposed in this investigation. In the proposed procedure, sodium hydroxide was utilized as the carrier stream, and aqueous cyanide solutions were forced into the prepared, packed column reactor on-line. Forming a cadmium compound as a cyanide complex resulting from the direct reaction between free cyanide and $CdCO_3$ and presented in the eluent can be determined as analyte using FAAS instrument. A pH of 10, the carrier flow rate of 3.5 mL/min, and a temperature of 20 ◦C were chosen as an optimum condition for a simple system proposition. The obtained results showed that the free CN- ion quantity directly increase the recorded absorbance in the examined sample. The recorded linear range (LR), the limit of detection, sampling rate, relative standard deviation, and recovery of the used procedure were 15 mg/L, 0.2 mg/L, 72 h^{-1}, 1.22%, and close to 100%, respectively. Several anions such as $S_2O_5^=$, $S_2O_8^=$, $CO_3^=$, $C_2O_4^=$, $B_4O_7^=$, $SO_3^=$, $SO_4^=$, SCN^-, NO_3^-, N_3^-, Cl^-, F^-, I^-, and CH_3COO^- were investigated as interferences during the reaction between free CN^- and $CdCO_3$. The results in the proposed FIA system showed to be new, stable, cheap, readily available in every laboratory in terms of the uses of $CdCO_3$ as the primary reagent. **Figure 5** showed detailed information on the proposed single-line flow system diagram combined with FAAS (Noroozifar et al., 2005).

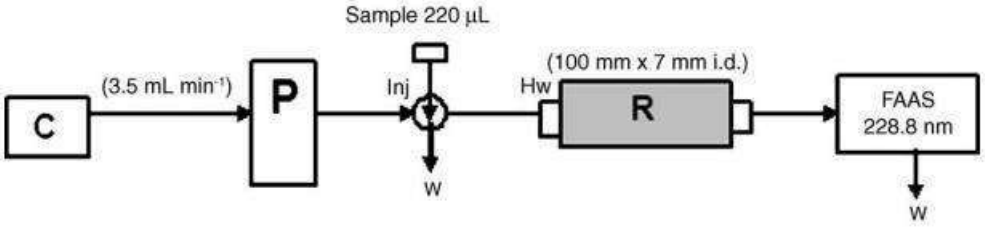

Fig.5: shows the simple components of the system combined with FAAS used to quantify free cyanide. C, carrier; P, pump; W, waste; Inj, injector; R, it is the SPR; Hw, glass wool plug and haply nut; and D, detector(Noroozifar et al., 2005).

In addition, a practical solid-phase reactor, which consists of the homogenized mixture of zinc carbonate ($ZnCO_3$) packed on silica gel beads, was also prepared and suggested for indirect cyanide investigation in industrial wastewaters using FIA-FAAS. In the proposed method, aqueous cyanide or sample solutions were inserted onto the on-line reactor, and the used carrier stream was re-distilled water. Zinc cyanide complexes, which were formed throughout the reaction between $ZnCO_3$ in the reactor and free cyanide at room temperature (pH of 6.0), were presented as a new form of analyte in the eluent and then determined by FAAS (Noroozifar et al., 2006). The measured absorbance was increased. The used $ZnCO_3$ chemical in the reactor's preparation is known as a safe, cheap, stable, and readily available reagents. The results data confirmed that the pH of 6.0, a suitable carrier flow rate (2.5 mL/min), room temperature (25°C) were selected as an optimal FIA system condition. **Figure 6** showed the proposed FIA system's simple diagram with complex components (Noroozifar et al., 2006).

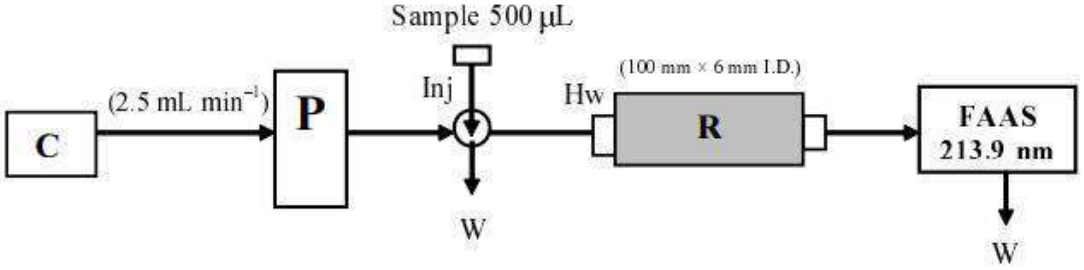

Fig.6: illustrates the main components related to the proposed flow system applied to quantify free CN^- ion. C, carrier; P, pump; Inj, injector; W, waste; Hw, glass wool plug; R is an SPR; FAAS, detector(Noroozifar et al., 2006).

Furthermore,Noroozifar, Khorasani-Motlagh, and Zare-Dorabei (2007)studied four solid-phase reactors for indirect monitoring and analyzing of free CN^- ion in various real industrial effluent using FIA-FAAS. The used solid-phase reactors were used as effectively packed columns and prepared from immobilized Ag_2X (X are $Cr_2O_7^{2-}$, CO_3^{2-}, $C_2O_4^{2-}$, and SO_3^{2-}) mixing with silica gel beads. During analysis (**Figure 7**), the sample solution, including dissolved CN^- is introduced into an on-line system, including Ag_2X with the used deionized water or NaOH as the productive carrier stream. The eluent solution includes silver cyanide complexes formed from the free silver ion's reaction with the free cyanide and can then be analyzed as a FAAS analyte. The results confirmed that the rising in the recorded absorbance is dependable on the changing anions in the Ag_2X formula and ordered as follows: $CO_3^{=}$> $C_2O_4^{=}$> $Cr_2O_7^{=}$> $SO_3^{=}$. The proposed method is selected as an appropriate method to determine cyanide ion due to using Ag_2X as stable, cheap reagents, and readily available as different forms in every laboratory (M Noroozifar et al., 2007).

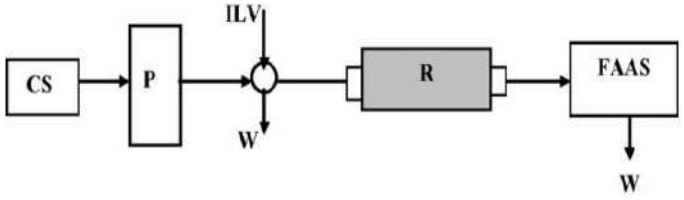

Fig.7: illustrates the main parts of FIS combined with FAAS to quantify free CN^-. CS, carrier stream; P, pump, R, solid-phase reactor; ; ILV, injector loop valve; FAAS, detector; W, residue waste (M Noroozifar et al., 2007).

Dadfarnia et al. (2007) recommended a rapid, simple, and applicable FIS for indirect quantification of cyanide by FAAS. A new microcolumn was proposed as a novel procedure for the indirect quantification of dissolved trace CN ions in different aqueous systems. The column was prepared from a mixture of Salen I on sodium dodecyl sulfate (SDS)-coated alumina saturated with Ag(I) ion. After sample injection into the microcolumn (pH 9–11), the silver solution was formed and eluted as silver-cyanide complexes and detected by FAAS. The recorded data revealed that the suggested procedure could be readily utilized in different real samples and provide a lower detection limit than previously documented FI-FAAS methods for indirect trace quantification of CN^- ion (Dadfarnia et al., 2007).

A rapid FI-FAAS was additionally proposed and improved by Noroozifar et al. (2008) for indirect quantification of dissolved cyanide in electroplating wastewater. Various solid phase reagents (SPRs) such as AgX (where X is N_3^-, Br^-, Cl^-, and I^-) were examined during analysis. In the

proposed method, five SPRs, which were mixed with silica-gel beads and various AgX SPRs, were prepared for the final assessment. In a single-line FIA system (**Figure 8**), the suggested procedure was depended on CN^- ion reaction from the injected sample with immobilized AgX SPRs in the SPR, followed by silver formation cyanide complexes in a basic medium carrier stream and later analysis of the eluent by FAAS. The results revealed that the absorbance could be increased due to changes in the use of different anions as follow order: N_3^-> I^-> Br^-> Cl^-. Based on the results, AgN_3 is proposed as an effective SPRs for the indirect analysis of CN^- ion in many industrial residues (Noroozifar et al., 2008). Obtained results verified that the measurement of cyanide by the proposed method appeared to be acceptable and favorable relative to obtained results by the previously documented methods. This comparison is based on several factors, including the methods simplicity, sensitivity, speed, cost, the limit of quantitation (LOQ), dynamic range, and relative standard deviation (RSD %). **Figure 8** shows the simple FIA system's main components combined with FAAS (Noroozifar et al., 2008).

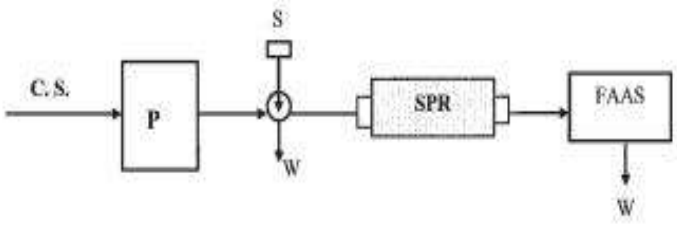

Fig.8: Shows the main parts of the FI-FAAS system for CN^- analysis (C.S., carrier stream; P, pump; S, sample; SPR, reactor; FAAS, detector; W, waste (Noroozifar et al., 2008).

In the another study, a new, cheap, simple, safe, and single-line FIA system method to indirectly quantify free cyanide in industrial wastewaters has been proposed by Noroozifar et al. (2009). The proposed method was designed and applied based on the aqueous cyanide solution through an on-line packed column (reactor), which included silver phosphate suspended on silica gel beads. The free silver ions are then reacted with the presented cyanide ion in the sample solution to form the soluble complex compound in the basic medium. The analyte, which is cyanide, can be indirectly measured utilizing the FAAS instrument. The proposed method is appropriate for quantifying cyanide in several industrial wastewater samples with a good detection limit, dynamic range, RSD, and sample flow rate (Noroozifar et al., 2009).

For the first time, a cloud point extraction (CPE) method was effectively applied for the isolation, preconcentration, and indirect measurement of CN^- ion in several water samples using FAAS (Gürkan & Yılmaz, 2013b). In the presence of CN^- ion, the reduction of Cu(II) (coming from the standard Cu(II) solution) to Cu(I) happens to produce $Cu(CN)_4^{3-}$ complex anionic ions. Then, a new ion-associate complex $[(NBO)_3Cu(CN)_4]$ is formed after the complexation reaction between the produced anionic complex with 3-amino-7-diethylamino-8,9-benzo-2-phenoxazine chloride (Nile blue, NB). Finally, the quantification analysis of cyanide is indirectly carried out by FAAS after using polyethyleneglycol mono-p-nonyl phenyl ether (PONPE 7.5). The PONPE 7.5 compound acts as an efficient extracting reagent/surfactant to the final complex at pH 5.5 medium (Gürkan & Yılmaz, 2013b).

Gürkan and Yılmaz (2013a) also developed a novel procedure for the indirect measurement of dissolved trace CN^- employing FAAS in various real waters sample. Among them includes river water, well water, hospital effluents, coking unit, and electroplating wastewater. In the proposed method, the cyanide ion presence can be efficiently quantified utilizing FAAS after separation and preconcentration with the CPE procedure. In this method, dicyanocuprate (Cu(I) $(CN)_2$) complex is produced due to the reduction of Cu(II) to Cu(I) with the dissolved CN^- ion in the sample solution. At pH 4.0, a useful ion-pairing reagent (gallocyanin, GCþ) can react with the produced dicyanocuprate compound to form a new complex. The product is easily extracted by polyethyleneglycol mono-p-nonylphenylether (Ponpe 7.5), extracting surfactant, and then quantified by FAAS technique. CPE-FAAS system was introduced as an effective indirect quantification method for separation, preconcentration, and monitoring trace cyanide in various aqueous systems. This technique was well-applied due to its low cost, simplicity, wide linear range, short analysis time, reasonable accuracy and precision, broad applicability, rejection of matrix constituents, and ease of instrumentation (Gürkan & Yılmaz, 2013a, 2013b).

Detailed analytical performance properties on the indirectly used measurement of free cyanide ion by FIA-FAAS in the last and this century are shown in **Tables 3**

and **4**, respectively. Analytical parameters such as methods linear range (LR), limit of methods detection (LOD), the limit of quantification (LOQ), relative standard deviation percent (RSD%), correlation coefficient (R^2), recovery, and sampling rate were shown and compared with each other(**Tables 3** and **4**). Recorded results from previous studies verified that FIA-FAAS could be applied to quantify the free cyanide in various real environmental samples (Gomez & Calatayud, 1998; Noroozifar et al., 2008). In comparison with other techniques, researchers confirmed that FIA-FAA offers promising results to quantify free cyanide in matrix samples (Dadfarnia et al., 2007). This technique is well known as simple, fast, widely applicable, more sensitive, and selective, high accurate, wide linear range, avoiding matrix constituent's methods during application based on previously documented studies. This technique also has several valuable points associated with the economy, such as its simplicity, low-cost reagents, and high analysis speed rate. This technique is preferable for the routine analytical assessments due to its simplicity and applicability.

However, this method also has some disadvantages. Several parameters have to be concerned to enhance cyanide assessment while using this technique. Among them includes controlling pH of the medium, sample or reagents flow rate, carrier stream pH, and loop volume (Dadfarnia et al., 2007). Besides, using such reagents related to toxic heavy metals can contaminate the environment (Noroozifar et al., 2005; Noroozifar et al., 2009; Noroozifar et al., 2008; M Noroozifar et al., 2007).

Table 3: shows the analytical performance properties of an indirectly measured free cyanide ion in various samples using FAAS documented from the last century

Preparation method	**Analytical method**	**LR (mg/L)**	**LOD (mg/L)**	**LOQ (mg/L)**	**R^2**	**RSD%**	**Recovery %**	**Sampling rate (sample/h)**	**Analyzed Samples**	**References**
Sample: including cyanide ion Reagents: $CuSO_4$, Na_2CO_3 Medium: a pH of 10.0 Analysis: $Cu(CN)_3^-$ ion complex	AAS /complex ion formation	0.52 – 1.1	NA	NA	NA	NA	96.7 - 103	-	Synthetic samples	(Manahan & Kunkel, 1973)
Packed column: CuS Carrier: KOH solution Medium: at the pH of 11 Analysis: cuprocyanide complex	FI-AAS	2.6 - 52	1.00	2.6	NA	2	NA	40-50	Synthetic samples	(Haj-Hussein et al., 1986)
Sample: free cyanide ion Medium: alkaline at pH 8.2 Reagents: BPTC Extraction solv.: IBMK: isopentanol Analyses: [Cu(BPTC)(CN)]	FAAS /based on extraction	0.4 - 5.7	0.005	0.026	NA	3.58	96.7 - 101	-	Industrial waste effluent	(Chattaraj & Das, 1991)
Precipitating agent: AgNO3 Washing: deionized water Dissolving agent: $NH_3/S_2O_3^=$ Analysis: liberated cation	FI-AAS Using $S_2O_3^=$ NH_3	Up to 4.4	0.078 0.13	NA	NA	1.4 1.7	NA	18 16	Synthetic samples	(Esmadi et al., 1993)
Measurement-based on extraction Metal ions; $Cu(CN)_3^{2-}$ or $Ag(CN)_2^-$ Reagent: Cetalkonium chloride Extractant: IBMK (at pH 10 or 11) Analyses:	FAAS For Cu	0 - 0.2	0.0006	NA	NA	NA	93	-	synthetic samples, drinking water, river water sea water	(Fullana-Barcedó et al., 1995)
	FAAS For Ag	0 - 0.3	0.0017	NA	NA	NA	99	-		

$[C_{25}H_{46}N^+]_2[Cu(CN)_3^{2-}]$ or $[C_{25}H_{46}N^+][Ag(CN)_2^-]$ complex										
Reactor: AgI& polymeric resin Medium: KOH solution at pH 13.7 Analysis: silver cyanide complexes	FIA-FAAS	0.2–6.0	0.1	NA	0.9974	0.8	NA	193	Pharmaceuticals, industrial electrolytic baths	(Gomez & Calatayud, 1998)

NA; none available,

Table 4: shows the analytical performance properties of an indirectly measured free cyanide ion in various samples using FAAS documented from this century

Preparation method	**Analytical method**	**LR (mg/L)**	**LOD (mg/L)**	**LOQ (mg/L)**	**R^2**	**RSD%**	**Recovery %**	**Rate (sample/h)**	**Sample matrix /application**	**References**
Analyte: sodium cyanide & sample Reactor: $CdCO_3$& silica gel beads Medium: at pH of 10.0 (20°C) Analysis: zinc cyanide complexes	FIA–FAAS	up to 15	0.2	NA	0.998	1.2	98.2 - 101	72	Industrial wastewaters	(Noroozifar et al., 2005)
Analyte: free cyanide Reactor: $ZnCO_3$& silica gel beads Medium: at pH of 6.0 (25°C) Analysis: zinc cyanide complexes	FIA-FAAS	Up to 25	0.12	NA	0.9995	1.41	98.3-101.8	65	Industrial electroplating wastewater	(Noroozifar et al., 2006)
Analyte: cyanide ion from sample Reactor: Ag_2X & silica gel bead X = $Cr_2O_7^=$, $CO_3^=$, $C_2O_4^=$, and $SO_3^=$ Medium: at pH range of 5–11 Analysis: silver cyanicde complexe	FIA-FAAS Ag_2SO_3 $Ag_2Cr_2O_7$ $Ag_2C_2O_4$ Ag_2CO_3	 Up to 20 Up to 10 Up to 10 Up to 12	 0.13 0.08 0.06 0.04	 0.38 0.22 0.17 0.14	 0.999 0.999 0.999 0.999	<1.12	98 - 100.5	 180 180 180 240	Industrial electrolytic baths.	(M Noroozifar et al., 2007)
Microcolumn: Salen I on SDS-coated Al with Ag^+, pH (9–11) Analysis: silver cyanide complex	FI-FAAS	0.1–10	0.06	0.1	0.9997	4.1 – 4.7	95 - 105	-	Water and industrial wastewater	(Dadfarnia et al., 2007)
SPR: AgX (X= Cl^-, Br^-, I^- and N_3^-) Reaction: SPR with free cyanide Medium: at pH 9.0 and 11.0 for Measurement: liberated silver ions complexed by the free cyanide ion	FIA-FAAS AgCl AgBr AgI AgN_3	 Up to 25 Up to 25 Up to 30 Up to 20	 0.17 0.14 0.08 0.05	 0.59 0.43 0.40 0.30	 0.996 0.994 0.998 0.999	< 1.09	98.8-102.4	>200	Industrial electroplating wastewater	(Noroozifar et al., 2008)
Analyte: cyanide ion from sample Reactor: Ag_3PO_4& silica gel	FIA-FAAS	0.1 - 18	0.04	0.1	0.998	1.07	95 - 104.2	220	industrial wastewaters	(Noroozifar et al., 2009)

bead Analysis $Ag(CN)_2^-$ at pH of 11										
Analyte: cyanide ion Reduction: Cu(II) to Cu(I) Product: $[Cu(CN)_4]^{3-}$ complex ion Ion-pairing reagent: Nile blue Extracting agent: Ponpe 7.5 Result: complex formation (pH 5.5)	CPE/FAAS (W/ PC)	0.02–2.5	0.0038	0.012	0.9940	3.54-2.80	97.5 - 99.4	-	Environmental waters and wastwaters	(Gürkan & Yılmaz, 2013b)
	CPE/FAAS (W/O PC)	0.1–7.5	0.025	0.085	0.9968	3.45-2.50	98.3-101.4	-		
Analyte: free cyanide Reduction: Cu(II) to Cu(I) Product: Dicyanocuprate (I) Ion-pairing reagent: GCþ (pH 4.0) Extracting agent: Ponpe 7.5	CPE/FAAS (W/ PC)	0.002–1.2	0.0005	0.0015	0.9983	2.3 – 5.2	97.6 - 99.5	-	Environmental waters and wastwaters	(Gürkan & Yılmaz, 2013a)
	CPE/FAAS (W/O PC)	0.05–6.5	0.014	0.047	0.9975	2.1 – 5.0	98 - 100.6	-		

CPE; cloud point extraction, W/ PC; with preconcentration method, W/O PC; without preconcentration method, SPR: solid-phase reagents which are insoluble silver salts,

IV. CONCLUSION

Cyanide species can be indirectly and easily quantified in the routine laboratory utilizing FAAS equipped with FIA in several environmental samples. The indirect measurement of free cyanide using FAAS provides several advantages: ease of applicability, simplicity, low cost, good recovery, selectivity and sensitivity, a wide linear range, number of sample analyses, and preventing matrix components. This approach offers an appropriate alternative to the indirect quantification of cyanide species as it provides ease of availability and instrumentation in various environments.

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Efficiency of removal Cr(III), Ni(II), Pb(II) ions from simulated wastewater using natural and modified Ca - bentonite

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Abstract— *The aim of this study was to investigate removal efficiency of heavy metals and the adsorption capacity of natural Ca-bentonite, as well as thermally and acid-activated Ca-bentonite (with HCl and H_2SO_4) for the removal of heavy metal ions Cr(III), Ni(II) and Pb(II). The adsorbent used is bentonite from the Shipovo (Šipovo mine), Bosnia and Herzegovina. The results show that the efficiency of heavy metal ion removal using Ca-bentonite is at a satisfactory level. Thus, the highest percentage of removal for the tested metals was at the highest concentration of 20 mg/L, while the decrease in concentration decreased the efficiency of removal of heavy metal ions. The highest percentage of removal was recorded for Cr(III) ions, while the lowest was for Ni(II).*

Keywords— ***adsorption capacity, Ca-bentonite, heavy metals, removal efficiency, wastewater***

I. INTRODUCTION

Examining the presence and methods of removal of heavy metals in both wastewater and drinking water has interested many scientists, resulting in many scientific papers. Heavy metals enter wastewater naturally and by human influence. The natural influence include soil erosion, volcanic activities, urban run offs and aerosols particulate, while the human influence include metal finishing and electroplating processes, mining extraction operations, textile industries and nuclear power [1]. Industrial wastewaters contains certain toxic and harmful pollutants, such as organic pollutants, inorganic pollutants and biological pollutants. The most important inorgnic pollutants include elements such as Cr, Cd, Cu, Ni, Pb, As, and Zn [2]. Heavy metals are highly soluble in the water and therefore they can be absorbed easily by living organisms [3]. The exposure of humans to heavy metals can occur through a variety of routes, which include inhalation as dust or fume, vapourisation and ingestion through food and drink [4]. The most common treatments for removing heavy metals from wastewater include chemical precipitation, membrane filtration, ion exchange, adsorption, and co-precipitation/adsorption [5]. The

adsorption process is widely used for the removal of heavy metals from wastewater because of its low cost, availability and eco-friendly nature [6]. This process involves a mass transfer by which a substance is transferred from the liquid phase to the surface of a solid and becomes bound by physical and/or chemical interactions [7]. New types of electronic bonds are created by this interaction [8]. Adsorption has been proved to be the best process of water treatment because of its significant advantages [9]. The use of different adsorbents has become a subject of great interest, and there have been continuous efforts to develop new, low-cost, and efficient adsorbent materials [10]. Adsorbent materials include the use of activated alumina, silica gel, carbons, zeolites, polymers, clay and bentonite.

Bentonite is an absorbent aluminium phyllosilicate, which is essentially impure clay consisting mostly of montmorillonite [11]. The bentonite is a widely available and abundant natural mineral, and can be a low cost adsorbent for water and wastewater treatment [12]. This adsorbent is considered as the best candidate for sorption of different kinds of emerging pollutants due to the excellent sorption, physical and chemical properties of bentonite and the ability of modifying bentonite. This can result in an increase in the sorption capacity for different types of pollutants such as heavy metals [13].

Moosa at al., (2015) reported that using bentonite, the maximum Cr(III) removal efficiency was 99.83% for crude bentonite at a concentration of 100 mg/L; 99.84% for thermally activated at a concentration of 75 mg/L; 99.80% for acid-activated bentonite at a concentration of 50 mg/L and 99.83% for thermally and acid-activated bentonite at a concentration of 25 mg/L [14].

Talaat at al., (2011) reported that the highest adsorption capacity for Cd (II), Cu (II), Zn (II), Ni (II), Pb (II) was achieved using Ca-bentonite, and Na-bentonite was most favorable for Cr (III) adsorption [15].

Melichová & Hromada (2013) studied the adsorption properties of natural bentonite from Lieskovac (Slovakia) for the removal of Pb(II) and Cu(II) ions from aqueous solution in a serial adsorption system. The amount of metal ion adsorption was found to increase with initial pH solution, metal ion concentration and contact time, but decreased with the amount of adsorbent. The maximum adsorption capacity of the adsorbent for Pb(II) and Cu(II) ions was obtained from the Langmuir isotherm and was 11.34 mg/g. [16a].

II. METHODS

Determination of the basic composition of Ca-bentonite by X-ray fluorescence

An S8 TIGER 4K spectrometer (X-ray fluorescence wavelength - WDXRF) with X-ray tubes, Rh anode, two collimators (0.23° and 0.46°) and five crystals for analysis was used to determine the elemental composition. The SPECTRAplus software package was used to interpret the WDXRF spectrum. The dried sample is ground in a mill, sieved through a 2 mm sieve, the sample fraction <2 mm is used for analysis.

Determination of heavy metal content in Ca-bentonite

To determine the content of heavy metal ions in Ca-bentonite, the standard method was used as follows. 1 g of Ca-bentonite was digested in a mixture of HNO_3 and HCl, 3:1. After 24 hours, the sample was filtered. The filtrate obtained was then analyzed on an atomic absorption spectrophotometer.

Determination of pH of Ca-bentonite

After a suspension of 4 g of Ca-bentonite and 20 mL of distilled water was homogenized for 1 hour, the pH of the solution was measured.

Determining the point of zero charge

A 50 mL batch of 0.1 mol/L $NaNO_3$ electrolyte solution was made in the pH range of 2 to 10, and the pH of the solution was measured and labeled as pHi. Then 0.2 g of Ca-bentonite was added to a series of $NaNO_3$ electrolyte solution and the suspension was left for 24 hours with occasional homogenization. After 24 hours, the pH of the solution was measured again and labeled as pH_f. Based on the measured values, a diagram $pH_f = f(pH_i)$ is created. The pH value that has not changed during 24 hours represents the pH point of zero charge.

Thermal activation of Ca-bentonite

Activation of bentonite by thermal means was performed by annealing at a temperature of 300 °C for 3 hours. The result of annealing is thermally activated Ca-bentonite which is used to remove heavy metal ions from simulated aqueous solutions.

Acid activation of Ca-bentonite

Two strong acids were used for the acid activation of Ca-bentonite, namely HCl and H_2SO_4 with a quantitative concentration of 0.4 mol/L. Ca-bentonite was added to the acid solutions and stirring was continued for 8 hours at 200 rpm. After filtration, the filter paper was dried in an oven at 105 ºC for 4 hours and sieved through a 75 μm sieve.

Preparation of synthetic solutions of heavy metal ions

Synthetic aqueous solutions of heavy metal ions that simulate wastewater are prepared from certified reference materials at different concentration intervals for these metals. ***Table 1***. shows the initial concentrations (mg/L) of three heavy metal ions simulating wastewater.

Table 1. Initial concentrations of heavy metals

Metals	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Cr(III)	5	10	15	20
Pb(II)	5	10	15	20
Ni(III)	5	10	15	20

Heavy metal ion adsorption process

In 100 mL of a solution of heavy metal ions of different concentrations prepared as described above, 1 g of Ca-bentonite was added and continuous homogenization was performed for 6 hours at room temperature at a speed of 125 rpm. After the filtration process, the residual concentration of heavy metal ions after the adsorption process was determined in the filtrate. The process of adsorption of heavy metal ions (Cr(III), Pb(II) and Ni(II)) from synthetic aqueous solutions (which simulate wastewater) in this paper was performed using the following adsorbents: natural (crude) Ca-bentonite on which no modification was performed, thermally activated Ca-bentonite, acid-activated bentonite with 0,4 mol/L solution of HCl, acid-activated bentonite with 0.4 mol/L H_2SO_4 solution and the adorption procedure was performed for each individual adsorbent as described.

Determination of heavy metal content by atomic absorption spectrophotometry

The 240 Series Agilent Technology atomic absorption spectrophotometer was used to determine the residual concentration of heavy metal ions after the adsorption process.

III. RESULTS AND DISCUSSION

Results of determination of the basic composition of Ca-bentonite by X-ray fluorescence

Table 2. shows the results of determining the basic composition of Ca-bentonite by X-ray fluorescence shown over the corresponding metals.

Table 2. Chemical composition of Ca-bentonite expressed through oxides of the corresponding metals

Oxide content	mass, %
SiO_2	48,28
Al_2O_3	23,04
TiO_2	0,84
Fe_2O_3	4,52
K_2O	0,29
Na_2O	0,22
P_2O_5	0,014
MnO	0,018
CaO	5,92
MgO	1,98
SO_3	<0,02

The highest oxides contents in Ca-bentonite were SiO_2 and Al_2O_3. The results of the chemical composition were almost the same as the results published in previous studies [17], [18], [16b], [19]. The obtained values for SiO_2, A_2O_3, Fe_2O_3 (48.28%, 23.04%, 4.52%) show a similar trend in the results obtained by researchers Abdullahi and Audu who tested two samples of bentonite in parallel and were: (48,16% and 49.87% for SiO_2, 14.86 and 14.98% for Al_2O_3 and Fe_2O_3, respectively: 4.80% and 5.12%). Also the results obtained for SiO_2 are similar to the values reported by Newke et al., (45 weight%); Tabak et al., (48.35% by weight). However, in terms of Fe_2O_3 content, the results obtained are lower than those reported by Newke et al., (11.10 weight%) Tabak et al., (8.26 wt%), but are higher than those published by Kiviranta and Kumpulainen, (3.82% by weight). Laterite or "red earth" consists mainly of iron oxide. Accordingly, the values obtained for Fe_2O_3 in the paper indicate that a low concentration of laterite is present in Ca-bentonite clay. The Na_2O content of the Ca-bentonite sample has much lower values (0.22 weight%) than those reported in the literature by researchers Abdullahi and Audu (1.66 and 1.43 weight%); Newke et al., (2.7% by weight); Tabak et al., (3.65% by weight). The values of MgO and TiO_2 content are similar to those given by Abdullahi and Audu, (2.08 and 0.94% by weight, respectively); Newke et al., (2.5 and 1.68 weight%) while the MgO content values reported by Tabak et al. Are significantly higher (5.47 weight%). In their work, Kiviranta and Kumpulainen obtained higher values for SO_3 (0.7 weight%) compared to the values obtained in this paper (<0.02 weight%). By comparing the results obtained for MnO, in their work, Newke et al. Obtained slightly higher results, namely 0.15

weight%. Based on the above, it can be seen that it is a material that is a significant carrier of aluminosilicates. Since the highest values were recorded for SiO_2 and Al_2O_3, Ca-bentonite belongs to the group of refractory materials.

Results of determination of heavy metal content in Ca-bentonite

The content of heavy metals in the bentonite clay sample is shown in ***Table 3.***

Table 3. Content of heavy metals in Ca-bentonite

Elements in Ca-bentonite clay	Metal concentration (mg/kg)	Limit values for clay soil (mg/kg)
Zn	2,61	200
Pb	31,41	100
Cd	0,56	1,5
Ni	4,08	50
Co	9,86	60
Fe	2224,83	50000
Mn	30,56	1000
Cu	10,79	80
Cr	0,77	100

Limit values of the content of tested metals in the soil are prescribed by the Rulebook on Determination of Harmful and Hazardous Substances in Soil and Methods of Their Testing "Official Gazette of the Federation of BiH", No. 72/09. The Ordinance sets limits for the content of heavy metals for different soil textures (sandy, powdery and clayey) and is expressed in mg/kg. Since Ca-bentonite belongs to the family of clay minerals, only the limit values for clay soil are presented in the paper (***Table 3***.). Comparing the content of tested heavy metals with the limit values, it is clear that the concentrations of heavy metals in Ca-bentonite do not exceed the prescribed limit values. Accordingly, this natural material is very suitable for use in the adsorption process.

Results of determination of pH value of Ca-bentonite

The measured pH value was 8.86. Based on the literature data, it can be concluded that at high pH values the mobility as well as the solubility of heavy metal ions is very low. In general, the solubility as well as the mobility of heavy metals in the soil increases with the acidification of the soil. The pH value of the clay suspension has a strong influence on its technical applications and some important properties, including adsorption and rheological properties [20].

Results of determining the zero charge point

The zero charge point determined for Ca-bentonite is shown in the ***Figure 1***. The value of the zero charge point represents the pH value above which cation removal will be favored. A value of 8.27 can be seen in the figure, ie above this value, the removal of positively charged ions will be more efficient. By comparing the obtained results, it obtained a slightly lower value in its work 7.8 for natural clay [21].

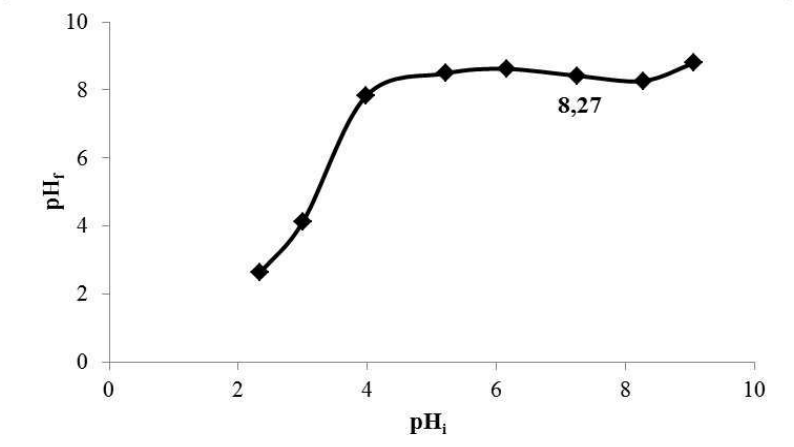

Fig.1. Zero charge point

Results of determining the optimal adsorption capacity

Removal efficiencies of heavy metals Cr(III), Pb(II) and Ni(II) treated with natural Ca-bentonite

Heavy metal ions removal efficiencies Cr(III), Pb(II) and Ni(II) whose initial concentrations ranged from 5 to 20 mg/L with natural Ca-bentonite are expressed as a percentage (%) and are shown in ***Figure 2***. The highest removal efficiency of heavy metal ions was in the order Cr(III)> Pb(II)>Ni(II) (98.56%, 96.03% and 81.50%) at an initial concentration of 5 mg/L. At a concentration of 20 mg/L, the removal efficiency was the lowest, in the order

Cr(III)> Pb(II)> Ni(II) (97.75%, 56.57%, 43.67%). Based on the ***Figure 2***., it can be conclude that with increasing concentration of heavy metal ions, the removal efficiency decreased. Comparing the obtained results with the results of the author [22a] concluded that an identical trend in behavior occurs, with an increase in the concentration of Cr(III), Pb(II) and Ni(II) there is a decrease in the ion removal efficiency of these heavy metals.

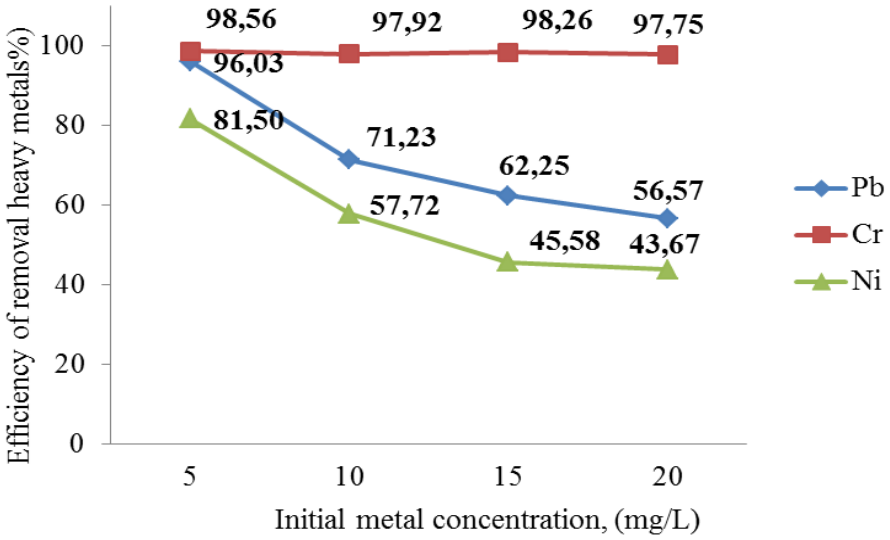

Fig.2. Efficiency of removal of heavy metal ions Cr(III), Pb(II) and Ni(II) treated with natural Ca-bentonite

Heavy metal ion removal efficiencies Cr(III), Pb(II) and Ni(II) treated with thermally activated Ca-bentonite

Similar results were obtained using thermally activated Ca-bentonite where the highest ion removal efficiency was in the order Cr(III)>Pb(II)>Ni(II) (98.08%, 94.15%, 84.24%) at an initial concentration of 5 mg/L. Similar results were obtained at an initial concentration of 20 mg/L, Cr (III)>Pb(II)>Ni (95.80%, 51.03% and 40.23%).

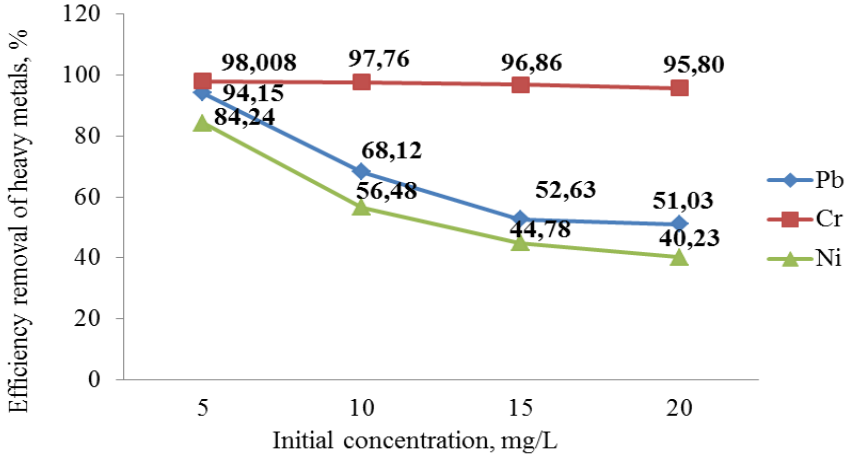

Fig.3. Efficiency of removal of heavy metal ions Cr(III), Pb(II) and Ni(II) treated with thermally activated Ca-bentonite

Removal efficiencies of heavy metals ions Cr(III), Pb (II) and Ni(II) treated with Ca- bentonite activated with H_2SO_4

The highest efficiency of heavy metal ion removal of 97.57%, 81.99%, and 60.37% was in the order Cr (III)> Pb(II)>Ni(II) at the lowest concentrations of these heavy metals, while at higher lower concentrations of heavy metal ion removal were observed in the concentrations and amounted to 86.02%, 60.95% and 36.04% for Cr(III), Pb(II) and Ni(II). [22b] investigated the influence of initial concentrations on the performance of the adsorption

process of natural and modified clay activated thermally and with acid (H_2SO_4). What was found is that with increasing concentrations, the adsorption capacity of clay samples (natural, acidic and thermally activated bentonite) for lead and chromium ions also increased. The increase in adsorption with increasing concentration of metal ions is the result of the driving force that the initial concentration allows to overcome the resistance of mass transfer between the aqueous and solid phases. The increase in adsorption capacity indicates that adsorbents have a high potential to remove Pb(II) and Cr (III) ions.

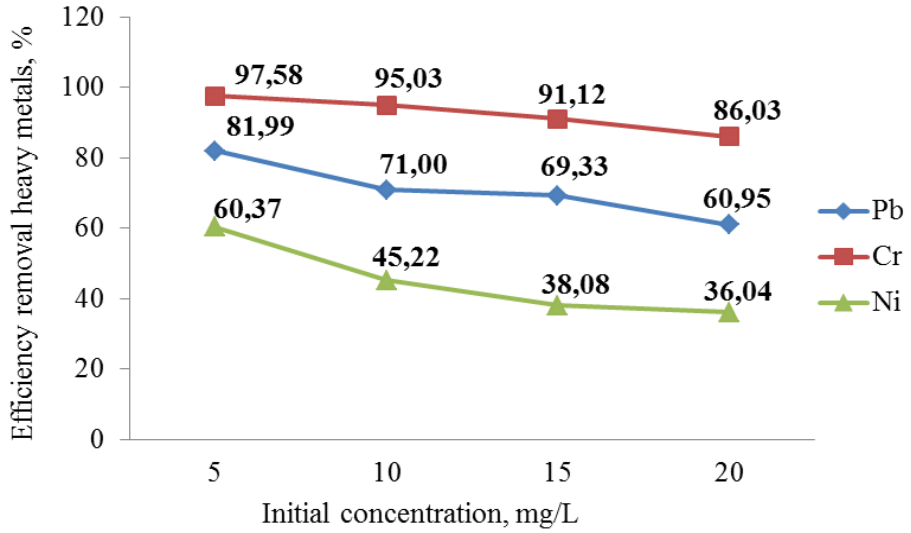

Fig4. Efficiency of removal of heavy metal ions Cr (III), Pb(II) and Ni(II) treated with thermally activated with H_2SO_4

Removal efficiencies of heavy metals ions Cr(III), Pb (II) and Ni(II) treated with HCl-activated Ca-bentonite

The highest removal efficiencies of 99.83%, 80.91%, and 71.81% for Cr(III), Pb(II) and Ni(II) were achieved at the lowest concentrations of these heavy metals, while at the highest concentrations the lowest removal efficiency: 96.30%, 48.50% and 36.65% for Cr(III), Pb(II) and Ni(II)

Based on the figures, as in the previous cases, it is clear that with increasing concentrations, the degree of efficiency of heavy metal ion removal decreased. The reason why this happens is that at one point Ca-bentonite is saturated with heavy metal ions. However, what still affects the obtained results is the mixing speed, which significantly affects the adsorption process. Ayari at all. (2007) obtained similar results in their study. They also investigated the influence of initial concentrations on the adsorption process. What was found is that with increasing concentrations, the adsorption capacity also increased, and the efficiency of heavy metal ion removal decreased [23].

One of the most commonly used adsorption isotherms to describe the adsorption process is the Freundlich adsorption isotherm. [24] The empirical model of this isotherm describes adsorption on a heterogeneous surface, where the constant Kf is a parameter related to the binding capacity of the adsorbate to the adsorbent and represents the adsorption strength, while the constant 1/n represents the surface heterogeneity factor. heterogeneity [25] [26].

Based on the data on the values of Freundlich isotherm given in the table, it can be concluded that the coefficient 1/n for all used biosorbents is less than one, which indicates that it is a large heterogeneous surface of used sorbents, ie that there are high energy sorption centers according to the examined heavy metal ions. The exception is the TAB for the adsorption of Ni(II) where this value is slightly higher than 1. The Kf constant values for all biosorbents used were about 10. For all analyzed biosorbents, the correlation factor (R^2) was 1, which further confirmed that the obtained values best describe the Freundlich adsorption model of the isotherm.

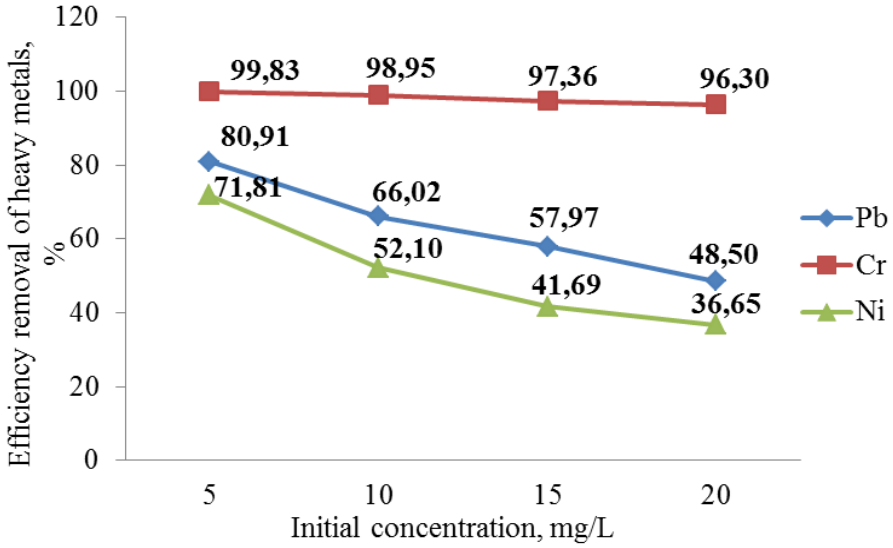

Fig.5. Heavy metal ion removal efficiencies Cr(III), Pb(II) and Ni(II) treated with Ca-bentonite activated HCl acid

***Values* of Freundlich constants**

Table 4. Values of Freundlich constants

Metal	Adsorbens	Kf	1/n	R^2
Pb(II)	NB	9,995396	0,9998	1
	TAB	9,993095	0,9997	1
	ABh	9,997698	0,999	1
	ABs	9,993095	0,9998	1
Cr(III)	NB	9,993095	0,9998	1
	TAB	9,995396	0,9998	1
	ABh	10	1	1
	ABs	9,993095	0,9998	1
Ni(II)	NB	9,995396	0,9998	1
	TAB	10,0023	1,0002	1
	ABh	9,997698	1	1
	ABs	10	1	1

Legend: NB – natural (raw) bentonite; TAB – thermal activated bentonite; ABh – acid activated bentonite with HCl; ABs – acid activated bentonite with H_2SO_4

IV. CONCLUSION

By applying natural, thermally and acid-activated Ca-bentonite, it is possible to remove Cr(III) Ni(II) and Pb (II) from the wastewater with a satisfactory degree of adsorption. The highest percentage of metal ion removal was achieved by removing Cr(III) with acid-activated bentonite with HCl and this percentage was 99.83% at a concentration of 20 mg/L. The highest percentage of Ni (II) removal was with the use of thermally activated bentonite and this percentage of removal was 84.24%. Natural bentonite proved to be the best for the removal of Pb(II) ions, and the percentage of removal was 96.03%. Cr(III) had a removal efficiency above 97% using natural, thermally and acid-activated Ca-bentonite, while Ni(II)

had a removal efficiency of 60.37% for acid-activated bentonite with H_2SO_4 to 84.24% with thermally activated bentonite.

Based on the data on the values of Freundlich isotherm it can be concluded that the coefficient 1/n for all used biosorbentsis less than one, which indicates that it is a large heterogeneous surface of used sorbents, ie that there are high energy sorption centers according to the examined heavy metal ions.

Based on the obtained experimental results, it can be concluded that Ca-bentonite was used from the area of Šipovo, Bosnia and Herzegovina can be used to remove heavy metal ions.

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Factors that Influencing Consumer Behavior against Rice Purchase Decisions

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Abstract— *The purpose of this study is to determine whether cultural, social, personal and psychological factors have a positive and significant effect also simultaneously on rice purchasing decisions and which consumer behavior factors have the most influence on rice purchasing decisions.This research was conducted in January 2022 and carried out on rice sellers. The respondents in this study were 55 rice buyers. This research uses accidental sampling method. Accidental sampling is a technique of determining a random sample that is accidentally encountered by a researcher at the research site. The results showed that (a) Cultural factors and personal factors did not have a positive and partially significant effect on rice purchasing decisions. Meanwhile, social and psychological factors have a positive and significant partial effect on rice purchasing decisions in Majene, West Sulawesi. (b) Cultural factors, social factors, personal factors and psychological factors have a simultaneous positive and significant effect on rice purchasing decisions in Majene, West Sulawesi and (c) Personal factors are the most dominant variables in influencing rice purchasing decisions because they have a t count and value. the highest significant.*

Keywords— ***Rice, Consumer Behavior and Purchase Decision Factors.***

I. INTRODUCTION

Rice is a staple food commodity that consumed by most of the Indonesian population. Quality problems are one of the important criteria for consumers in choosing the rice to be consumed. Rice consumers are now increasingly concerned with quality and see rice not only as a commodity but as a product with certain criteria. The main factor driving the high consumption of rice is the large population. Furthermore with the increasingly widespread area where the population consumes rice as a staple food. The many choices of rice products in the form of rice type, packaging, price, taste and other things as well as differences and influences from the cultural environment, social class, purchasing power, motivation and lifestyle build different consumer behavior. This requires producers to provide rice products that are in accordance with the wishes of consumers, especially the targeted market segment. There are several characteristics that demand the quality of rice, namely physical properties and milling properties, taste and cooking properties as well as nutritional properties. The appearance of rice, taste, and elasticity of rice can be represented by the physico-chemical properties of rice (Damardjati et al 2016). The reference used is the opinion of Suharsimi Arikunto (2004) which says that "for a population whose subjects are less than 120 respondents, it is better to take all of them, so that the research is a population study and then if the number of subjects is more than 120 respondents it can be taken between 10% - 15% of the total population. The sample used in this study were 52 respondents who were rounded up to 55 respondents, using the Slovin formula with e = 0.15 so as to produce 55 respondents.

II. MATERIALS AND METHODS

Table 2

Variable	operational definition	Indicator	Scale
Cultural factor (X1)	The habits or characteristics of a social group that distinguish it from other cultural groups	1. Product trust 2. Good and bad views on the product 3. The habit of hearing about the product 4. Habits choose product	Measured through a questionnaire using the Likert scale
Social Factor (X2)	A group of people who are able to influence individual behavior in carrying out an action based on habits.	1. The presence of friends to choose products 2. The presence of family members to choose products 3. The presence of parents or elders to choose product	Be measured through a questionnaire with use Likert scalet
Personal factor (X3)	One of the useful concepts in studying consumer behavior is that personality influences the type and brand of products purchased.	1. Work 2. State of the economy / income 3. Lifestyle 4. Product & Personality	Be measured through nominal scale
Psychological factor (X4)	The method used to recognize feelings, collect, analyze information and formulate thoughts and opinions in taking action	1. Motivation to choose a product 2. Perception to choose a product 3. Learning from experience so choosing a product 4. Confidence in the product	Be measured through a questionnaire with use Likert scale
Buying decision (Y)	Confidence when deciding whether or not to feel regret when buying a product	1. Product needs 2. Search for product information 3. Product evaluation 4. Product selection decision	Be measured through a uestionnaire with use Likert scale

III. RESULTS AND DISCUSSION

Respondent characteristics

Respondents from this study are consumers who make purchases of rice. The questions contained in this questionnaire consist of two parts, the first question regarding the identity of the respondent and questions regarding the four independent variables, namely social factors, cultural factors, personal factors, and psychological factors. In this section, the identity of the respondents based on gender, age, and occupation will be explained. The classification of respondents in this study aims to clearly determine the object of research. The general description of the research object is described as follows:

Tabel 2 Respondent profile data by gender

Gender	Frequency	percentage
Female	34	62%
Male	21	38%
Total	**55**	**100%**

Source: Output SPSS (2022)

Based on the profile data of respondents belonging to the gender group above, the number of male respondents is 21 people or in the form of a percentage of 38%. While the number of female respondents as many as 34 people or in the form of a percentage as much as 62%. If seen from these results, the number of female respondents is more than female respondents.

Tabel 3 Respondent profile data by age

Age (years)	Frequency	Percentage
11 – 20	1	1,8%
21 – 30	14	25,4%
31 – 40	13	23,6%
41 – 50	14	25,4%
51 – 60	9	16,3%
61 – 70	4	7,2%
Total	**55**	**100%**

Source: Output SPSS (2022)

Based on table 3 above, it can be seen that the number of respondents belonging to the above age group,

the number of respondents aged 11-20 years is 1 person or 1.8%, then respondents aged 21-30 years are 14 people or 25.4%, then respondents aged 31-40 years as many as 13 people or 23.6%, then respondents aged 41-50 years as many as 14 people or 25.4%, then respondents aged 51-60 years as many as 9 people or 16.3% and respondents aged 61-70 years as many as 4 people or 7.2%.

Tabel 4 Respondent profile data by occupation

Occupatuon	Frequency	Percentage
Civil servant	8	14,5%
entrepreneur	5	9,1%
housewife	6	10,9%
employee	9	16,3%
Etc	16	29%
Total	**55**	**100%**

Source: Output SPSS (2022)

Based on respondent profile data, grouped by occupation, the number of respondents who work as civil servants is 8 people or 14.5%, the number of respondents who work as entrepreneurs is 5 people or 9.1%, the number of respondents who work as IRT is 6 people or 10, 9%, the number of respondents who work as employees as many as 9 people or 16.3%, and respondents who work as other jobs as many as 16 people or 29%, it can be concluded that respondents who work as other professions are more dominant, namely 16 people or 29%.

Variable Descriptive Data Analysis

1. Cultural Factors Descriptive Data Analysis (X1)

Variable Cultural Factors discusses beliefs, good/bad views, desires and habits. Respondents' responses to Cultural Factors are summarized in the following table :

Tabel 5 Respondents' Assessment Data on Cultural Factors

No	Question	SS		S		R		TS		STS		Mean
		F	%	F	%	F	%	F	%	F	%	
1.	Good and comfortable (X1.1)	13	23,6%	29	52,7%	13	23,6%	0	0%	0	0%	4,00
2.	desire (X1.2)	11	20%	37	67,2%	7	12,7%	0	0%	0	0%	4,07
3.	habit (X1.3)	15	27,2%	33	60,6%	7	12,7%	0	0%	0	0%	4,15

This study uses a Likert scale consisting of 5 scores namely strongly disagree (1), disagree (2), doubtedly agree (3), agree (4), and strongly agree (5), in this case the measurement of trust is good and comfortable. can be measured using a reference score with the average results of respondents' answers. Based on the table above, it can be seen in the first question regarding Trust in buying rice (X1.1) with the average respondent's answer showing the number 4.00, which means the highest mean value on the X1 variable and is on the scale agree, strongly agree and in doubt means consumers trust rice products, then in the second question regarding desire (X1.2) the mean value of respondents with an average answer showing the number 4.07 is on the agree scale, meaning that the desire to influence consumers in shopping for rice, then on the question about the habit of listening to products (X1 .3) with a mean respondent value of 4.15, which is on the agree scale, meaning that consumers are accustomed to knowing about rice products from other people so they decide to choose/buy .

2. Descriptive Data Analysis of Social Factors (X2)

Social Factor variables discuss information, influence and welfare. Respondents' responses to social factors are summarized in table 6 below:

Table 6

No.	question	SS		S		R		TS		STS		Mean
		F	%	F	%	F	%	F	%	F	%	
1.	Information (X2.1)	8	14,5%	35	63,6%	9	16,3%	1	1,8%	0	0%	3,76
2.	Effect (X2.2)	2	3,6%	29	52,7%	21	38,1%	3	5,4%	0	0%	3,55
3.	Well-being (X2.3)	0	0%	24	43,6%	27	49%	4	7,2%	0	0%	3,36

Based on the results of the responses that have been summarized in the table above, it shows that those who have the mean are questions (X2.1) regarding information by showing an average number of 3.76 which is on the agree scale, meaning that information influences consumers to choose/buy a rice product, then the highest mean value is the question on the variable (X2.2) regarding the existence of family members with an average number of 3.55 with the most choices on the agree scale, meaning that family members influence consumers to choose/buy a rice product. While the question on the variable (X2.3) regarding welfare with the lowest 3.36 with an average number of 3.36 which is on the agree scale means that welfare affects consumers so that they choose/buy a rice product.

3. Personal Factors Descriptive Data Analysis (X3)

The Personal Factor variable discusses opinions, personal satisfaction and habits. Respondents' responses to personal factors are summarized in the following table: :

Tabel 7 Respondents' Assessment Data on Personal Factors

No.	Question	SS		S		R		TS		STS		Mean
		F	%	F	%	F	%	F	%	F	%	
1.	Opinion (X3.1)	6	10,9%	36	65,4%	11	20%	2	3,6%	0	0%	3,84
2.	satisfaction (X3.2)	7	12,7%	30	54,5%	16	29%	2	3,6%	0	0%	3,75
3.	habit (X3.3)	11	20%	21	38,1%	20	36,3%	3	5,4%	0	0%	3,73

Based on the table above, it can be seen in the first question regarding the opinion (X3.1) with the mean value of the respondent showing the number 3.84 is on the agree scale, meaning that opinion influences the purchasing decision of a product, then in the second question regarding individual satisfaction (X3.2) The respondent's mean value with an average answer shows the number 3.75 is on the agree scale, meaning that satisfaction alone affects the purchasing decision of a product, then on the question of self-concept/habits (X3.3) with a respondent's mean value of 3.73 is on the agree, it means that lifestyle influences the purchasing decision of a product.

4. Psychological Factors Descriptive Data Analysis(X4)

Psychological Factor variable discusses satisfaction, recommendation and purchase motivation. Respondents' responses to personal factors are summarized in the following table:

Tabel 8 Respondents' Assessment Data on Psychological Factors

No.	Question	SS		S		R		TS		STS		Mean
		F	%	F	%	F	%	F	%	F	%	
1.	Satisfaction (X4.1)	13	23,6%	29	52,7%	13	23,6%	0	0%	0	0%	4,00
2.	Recommendation (X4.2)	6	10,9%	29	52,7%	17	30,9%	3	5,4%	0	0%	3,69
3.	Motivation to buy (X4.3)	8	14,5%	37	67,2%	9	16,3%	1	1,8%	0	0%	3,93

Based on the table above, it can be seen in the first question regarding satisfaction (X4.1) with the mean value of respondents showing the number 4.00 is on the agree scale, meaning that rice consumers are motivated to choose/buy a product, then in the second question regarding recommendations (X4.2). The respondent's mean value with an average answer shows the number 3.69 is on the agree scale, meaning that the perception of rice products affects purchasing decisions, then on the question of buying motivation (X4.3) with a respondent's mean value of 3.93 is on the agree scale, it means consumers recognize the product because they often shop so they buy the product

5. Purchasing Decision Descriptive Data Analysis (Y)

The Purchase Decision Variable discusses Satisfaction, seeking recommendations, and purchasing. Respondents' responses to purchasing decisions are summarized in the following table:

Tabel 9 Respondents' Assessment Data on Purchase Decisions

No.	Question	SS		S		R		TS		STS		Mean
		F	%	F	%	F	%	F	%	F	%	
1.	Satisfaction (Y1)	3	5,4%	33	60%	18	32,7%	3	5,4%	0	0%	3,69
2.	Recommendation (Y2)	2	3,6%	34	61,8%	19	34,5%	0	0%	0	0%	3,69
3.	Purchase (Y3)	2	3,6%	42	76,3%	11	20%	0	0%	0	0%	3,84

Based on the table above, it can be seen in the first question regarding purchase satisfaction (Y1) with the mean value of respondents showing the number 3.69 is on the agree scale, meaning that the need affects the choice of rice products to be purchased by consumers, then in the second question regarding recommendations (Y2) The mean value of respondents with an average answer showing the number 3.69 is on the agree scale, which means that before making a purchase, consumers of rice seek first information related to the product, then on questions about product purchasing decisions (Y3) with a respondent's mean value of 3.84 is at agree scale means evaluating the product affects consumers when they have bought the product.

Validity and Reliability Test

1. Validity Test

Validity test is used to measure the validity of a questionnaire. Validity test is carried out after generating respondent's response data which generated from questionnaires that have been previously distributed. This research uses an analytical tool, called "SPSS" by using the Corrected item Total Correlation is large from r table or df = (N-2) = 55-2 = 53 = 0.266.

Table 10 Validity Test Result

No.	Variable	Total of Person Colleration	Note
1.	X1.1	0.594	Valid
2.	X1.2	0.432	Valid
3.	X1.3	0.346	Valid
4.	X2.1	0.284	Valid
5.	X2.2	0.309	Valid
6.	X2.3	0.281	Valid
7.	X3.1	0.594	Valid
8.	X3.2	0.304	Valid
9.	X3.3	0.477	Valid
10.	X4.1	0.465	Valid
11.	X4.2	0.290	Valid
12.	X4.3	0.278	Valid
13.	Y1.1	0.324	Valid
14.	Y2.2	0.293	Valid
15.	Y3.3	0.438	Valid

Source : output source of SPSS 25 (2022)

Based on the foregoing validity test result, using r table value of 0.266, all questions instruments for each variable show valid results as whole because of the Total of Person Correlation value shows number above from the r table value of 0.266, therefore it can be said that each of the five variables used researched is considered to be valid as a whole.

2. Reliability Test

Reliability test is a test used to measure the stability of the indicators of each variable in the questionnaire using the standard value of the Cronbach's Alpha coefficient of 0.60. Whereas a construct or variable is reliable if it provides Cronbach Alpha > 0.60 (Chozali, 2011). The following are the results of the reliability test for each variable:

A. Reliability Test Result for Cultural Factors (X1)

Table 11

Reliability Statistics	
Cornbach's Alpha	N Of Items
0.609	3

Based on the reliability test for Cultural Factors (X1) above, it has Cronbach's Alpha more than 0.60, which is 0.609. Thus, based on the foregoing, the indicators in this research are reliable.

B. Reliability Test Result for Social Factors (X2)

Table 12

Reliability Statistics	
Cornbach's Alpha	N Of Items
0,754	3

Based on the reliability test for Social Factors (X2) above, it has Cronbach's Alpha more than 0.60, which is 0.754. Thus, based on the foregoing, the indicators in this research are reliable.

C. Reliability Test Result for Personal Factors (X3)

Table 13

Reliability Statistics	
Cornbach's Alpha	N Of Items
0,795	3

Based on the reliability test for Personal Factors (X3) above, it has Cronbach's Alpha more than 0.60, which is 0.795. Thus, based on the foregoing, the indicators in this research are reliable.

D. Reliability Test Result for Psychology Factors (X4)

Table 14

Reliability Statistics	
Cornbach's Alpha	N Of Items
0.696	3

Based on the reliability test for Psychology Factors (X4) above, it has Cronbach's Alpha more than 0.60, which is 0.696. Thus, based on the foregoing, the indicators in this research are reliable.

E. Reliability Test Result for Purchasing Decision (Y)

Table 15

Reliability Statistics	
Cornbach's Alpha	N Of Items
0.681	3

Based on the reliability test for Purchasing Decision (Y) above, it has Cronbach's Alpha more than 0.60, which is 0.681. Thus, based on the foregoing, the indicators in this research are reliable.

Multiple Linear Regression Analysis

Table 16: Regression Calculation Results

Coefficients					
Model	Unstandardized Coefficients		Standardized Coefficients	t	sig
	B	Std. Eror	Beta		
(Constant)	19.666	.560		35.143	.000
Total of Cultural Factors	-.676	.352	-1.151	-1.921	.060

Total of Social Factors	.221	.442	.378	.500	.619
Total of Personal Factors	.156	.303	.270	.514	.609
Total of Psychology Factors	-.127	.468	-.218	-.271	.787

Source: Output SPSS 2022

Based on the result of regression calculations processed above, the effect of independent variable on the dependent variable is described with the following equation:

$$Y = b0 + b1\ X1 + b2\ X2 + b3\ X3 + b4\ X4 + e$$

$$Y = 19.666 + -0{,}676X1 + 0{,}221X2 + 0{,}156X3 + -0{,}127X4 + e$$

The following is the explanation of the abovementioned equation:

a. b0= shows a value which means if all the independent variables, such as cultural factors, social factors, personal factors, and psychological factors are constant, then the value of dependent variables shows the number of -0.260% as the value result of dependent variable therefore it can determine the purchasing decision.

b. 19.666 X1 = the value of 0.676 is the value which shows that Cultural Factors (X1) do not affecting positively towards the purchasing decision (Y), therefore each of addition of 1% feedback from respondent regarding the Cultural Factors (X1), therefore it will affects the variable (Y) that is the purchasing decision with the value becoming -0.676%.

c. 0,221 X2= the value of 0.221 is the value which shows that the Social Factors are positively affecting the purchasing decision (Y), therefore each of addition of 1% feedback from respondent regarding the Social Factors (X2), therefore it will affects the variable (Y) that is the purchasing decision with the value becoming 0.221%.

d. 0,156 X3= the value of 0.156 is a value which shows that Personal Factors (X3) do not positively affecting the rice purchasing decision (Y), therefore each of an addition of 1% of feedback from respondent regarding the Personal Factors (X3), therefore it will affects the variable (Y), that is the purchasing decision with the value becoming 0.156%.

e. 0,157 X4= the value of 0.157 is a value which shows that the Psychological Factors (X4) are positively affecting the purchasing decision of rice (Y), therefore each of an addition of 1% of feedback from respondent regarding Psychological Factors (X4), therefore it will affects the variable (Y), that is the purchasing decision with the value becoming 0.157%.

Hypothesis Test

A. Partial Test (t Test)

Partial test (t test) is a test that is conducted to determine the effect of each independent variable (X) partially on the dependent variable (Y). The following are the results of the research t test:

Table 17 Result t Test

Variable	T Count	T Table	Significance
Cultural Factors	-1,921	1673	0,000
Social Factors	.500	1673	0,000
Personal Factors	.514	1673	0,000
Psychological Factors	-.218	1673	0,000

Source: primary data processed by SPSS (2022)

If the value of t count > t table, therefore there is an effect of independent variable (X) towards the dependent variable (Y) or the hypothesis is accepted. Whereas if the value of t count < t table, therefore there is an effect of independent variable (X) towards the dependent variable (Y) or the hypothesis is not acceptable. The same thing if it viewed from the significance value of < 0.05 then the variable shall be considered significant. The following is the explanation for the foregoing table:

1. t court for Cultural Factors X -1.921 < t table 1.673 with the significance value of 0.000 which > 0.05 shall means that the Cultural Factors (X1) do not significantly affecting the purchasing decision. Therefore, we may conclude that the variable of

Cultural Factors (X1) dot the affecting partially towards the variable of purchasing decision.

2. t count of Social Factors (X2) 500 > t table 1.673 with the significance value of 0.000 which > 0.05 it shall mean that the Social Factors (X2) are significantly affecting the purchasing decision. Therefore, it may be concluded that the Cultural Factors (X2) do partially affecting towards the purchasing decision.
3. t count of Personal Factors (X3) 514 < t table 1.673 with the significance value of 0.000 which > 0.0.5 it shall mean that the Personal Factors (X3) do not affecting significantly towards the purchasing decision. Therefore, it may be concluded that the variable of Personal Factors (X3) do not partially affecting towards the purchasing decision.
4. t count of Psychological Factors (X4) - 218 > t table 1.673 with the significance value of 0.000 which < 0.05 it shall mean that the Psychological Factors (X4) do affecting significantly towards the purchasing decision. Therefore, it may be concluded that the variable of Psychological Factors (X4) do partially affecting the variable of purchasing decision.

B. Simultaneous Test (F Test)

Simultaneous Test is a simultaneous test of independent variables whether it has an effect on the dependent variables simultaneously or not. Below is the test result of F Test:

Table 18 Test F Result

ANOVA[b]						
Model		Sum Of Squares	Df	Mean Square	F	Sig.
1	Regression	213,830	4	53,457	14,889	.000[b]
	Residual	179,516	50	3,590		
	Total	393,354	54			

Source: Output SPSS (2022)

Based on the above table, the significance value of 0.000 < 0.05 which means it has significant effect. Based on the analysis it can be concluded that the independent variables of Cultural Factors (X1), Social Factors (X2), Personal Factors (X3), and Psychological Factors (X4) do affecting simultaneously towards the purchasing decision (Y).

C. Coefficient of Determinants

The coefficient of determination is a reference to measure the contribution of the influence of the independent variable (X) simultaneously on the dependent variable (Y), in this study the influence of Cultural Factors (X1), Social Factors (X2), Personal Factors (X3), and Psychological Factors (X4) will be measured. The following Table 19 is the result of coefficient of determination:

Table 19

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Eror Of The Estimate
1	.737[a]	.544	.507	.1.89481

Source: Output SPSS (2022)

Based on the foregoing coefficient of determination result, the value of R shows the value of 0.737 which close to value 1, therefore the coefficient of determination (R square) amounting to 0.737 x 0.737 = 0.544, therefore it can be said that the independent variable of Cultural Factors (X1), Social Factors (X2), Personal Factors (X3) and Psychological Factors (X4) do affecting simultaneously on the purchasing decision (Y) with the amount of 54.4%.

Partial Influence of Consumer Behavior on the Rice Purchasing Decisions

A. Cultural Decision (X1)

Based on the multiple linear regression test conducted, cultural factors have value of 286 which shall indicate that the cultural factors (X1) do not affecting the purchasing decision of rice, with the t count of 6.016 < t table 1.673 with the significance value of 0.159 which > 0.000, it means that the hypothesis 1 is not acceptable which means that partially the cultural factors (X1) do not significantly affecting the purchasing decision of rice. Hence, it can be concluded that the cultural factors do not positively and significantly affecting the purchasing decision of rice. This shall prove that the cultural

factors do not determine an individual or consumer in the decision process to purchase rice, this is obviously the basis that the cultural factors do not always influence the purchase decision therefore other factors play important roles in determine consumer behavior in their decision making.

This is consistent with the research conducted by Laela Nurrillyyin (2016), with the title "Factors that influence consumer behavior in the purchasing decision of instant noddle with hal label (Case study with students of UIN Sunan Kalijaga Yogyakarta)", whereas the research concluded that cultural factors do not influence the purchasing decision. Other research conducted by Widya Rambi (2015) stated that cultural factors do not significantly affecting the purchasing decision.

B. Social Factors (X2)

Based on the multiple linear regression test conducted, social factors have value of 787 which is a value that shows social factors (X2) influence the purchasing decision of rice, with t count of 10.544 > t table 1.673 with significance value of 0.000 < 0.05 which means that hypothesis 1 is acceptable, also means that partially the social factors (X2) have significant influence on the purchasing decision of rice. Therefore, in can be concluded that social factors have positive influence and partially significant on the purchasing decision of rice. This shows that the higher the relationship with friends, family and parents, the higher consumer decision on purchasing .

This is consistent with the research conducted by Syafirah (2017), with the title of "The Influence of Factors of Consumer Behavior on the Purchasing Decision of Products at Holland Bakery Manado", where this research concluded that social factors are significantly influence the purchasing decision of products at Holland Bakery Mando. This is also supported by another researcher Handy Noviyanto (2010), where social factors have significant positive influence on the purchasing decision.

C. Personal Factors (X3)

Based on the multiple linear regression test conducted, personal factors have value of 547 which a value that shows personal factors (X3) do not have influence in the purchasing decision of rice, with t count 13,618 < t table 1.673 with significance value of 0.000 > 0.05 which shall mean that hypothesis 1 is not acceptable and also mean that partially the personal factors (X3) do have significant influence on the purchasing decision of rice. Now, we can conclude that personal factors do not have positive and partial influence on the purchasing decision of rice. This finding is consistent with a research by Widya Rambi (2015), where personal factors do not have significant influence on the purchasing decision.

D. Psychological Factors (X4)

Based on the multiple linear regression test conducted, psychological factors have value of 603 which is a value that shows psychological factors (X4) influence the purchasing decision of rice, with t count of 4.895 > t table of 1.673 with significant value of 0.000 < 0.05 which means that hypothesis 1 is acceptable whereas it means that partially the psychological factors (X4) significantly influence the purchasing decision of rice. Therefore, it can be concluded that the psychological factors have positive influence and partially significant on the purchasing decision of rice. This shows that psychological factors which consist of motivation, perception, knowledge, belief and attitude that formulate thinking and thoughts on decision making. The higher the motivation, perception, knowledge, beliefs, and attitude of an individual towards a product, the higher the consumer decision to purchase.

This is consistent with a research by Sujani (2017), with the title of "The Influence of Consumer Behavior on the Purchasing Decision at Indomaret", where this research concluded that the psychological factors have significant influence on the purchasing decision at Indomaret. This research also supporting the claim by Supriyono and Dibyo Iskandar (2015), where the psychological factors have significant positive influence towards the purchasing decision.

The Influence of Consumer Behavior Simultaneously Towards Purchasing Decision of Rice

Based on the statistical analysis conducted to the variables in this research, both independent (X) and dependent (Y), where the test result of F test is 0.000 therefore less that alfa 0.05. This figure shows that, simultaneously, the independent variables Cultural Factors (X1), Social Factors (X2), Personal Factors (X3), and Psychological Factors (X4) have significant influence towards the purchasing decision (Y). Therefore, in can be concluded that cultural, social, personal, and psychological factors have positive and simultaneous significant towards the purchasing decision of rice.

The Dominant Variable which Influence the Purchasing Decision of Rice

Based on the multiple regression test which from t count of each variable, cultural factors (6,016), social factors (10,544), personal factors (13,618), and psychological factors (-7,366). Now, it can be seen that the highest coefficient regression is the personal factors. Therefore, the variable of psychological factors have the most dominant in influencing the purchasing decision of rice because it has the highest t count and significant value.

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Effects of cut back at different leaf phenology stages on the growth of scion of rubber seedlings

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Abstract— *Phenology can directly reflect the characteristics of rubber seedling, people can determine the agricultural time arrangements of seedling germination, cut back, tending management and nursery operation. In this study, the phenological period of the top leaf of hevea tree seedlings was divided into four treatments, and cut back was carried out in sprout period, bronze stage, light green stage and stable stage, respectively. The effects of sawing stock in different phenological periods on the budding rate and growth potential of scion 1-2 were observed. The results showed that the budding rate and nursery rate of scion were significantly higher than those of other stages when the leaf phenology stage was sawed in sprout stage and stable stage, and the budding rate and nursery rate were the lowest in the light green stage. In the first leaf whorl, the plant height of stock leaf phenology stage was significantly higher in sprout stage and bronze stage than in light green stage, but there was no significant difference with stable stage; The stem diameter of stable phenological stage was significantly larger than that of bronze and light green phenological stage, but there was no significant difference with that of sprout stage; The leaf whorl distance in the paleobronze period was significantly higher than that in the light green period, but there was no significant difference with other periods; The number of leaves in phenological stage was significantly more in sprout stage than in light green stage, and there was no significant difference from other stages. In the second leaf whorl, The plant height, stem diameter, leaf distance and leaf number of scion of stock seedlings in phenology stage were significantly higher than those in other stages, and the growth of stock seedlings in light green stage was lowest. In conclusion, the leaf phenology stage of the rootstock seedlings of rubber tree is in the sprout stage, and the scion growth is the best, followed by the stable stage and bronze stage. Cut back in the light green stage is not recommended.*

Keywords— ***Hevea brasiliensis, Leaf phenology, rootstock seedling, Growth.***

I. INTRODUCTION

Plant phenology refers to the habit of ecological and physiological functions with regular changes due to long-term adaptation to natural changes in the evolutionary process of organisms, that is, biological activities can change with climate change.People can understand the climate change through the dynamic changes of its life activities, including the germination of plants, leaf

development, flowering, leaf discoloration, defoliation and other phenomena(Ge Quansheng et al,2010;Lu Peiling et al,2006).In the second edition of Rubber Cultivation in 1979,Rubber tree according to the leaf conditions of the top of the leaf is divided into budding stage, bronze stage, light green stage and stable stage(Huang Zongdao,1979).Each leaf whorl of a rubber tree passes through these seven phases before the next leaf begins to grow.

It has been reported that the phenological period of rubber tree is related to stress resistance, physiology, biochemistry and nutrition. Liu Suqing (1996) used powdery mildew agent to study powdery mildew fungus in different phenological stages of rubber trees and showed that powdery mildew on leaves of rubber leaves in bronzing and discoloration stages had obvious inhibitory effect.Tao Zhonghua et al. (2009) studied the leaf mass element content in different phenological stages of high-yielding new varieties of rubber trees.In general, nitrogen and phosphorus were similar, and gradually decreased from germinating stage to light green stage, while gradually increased from light green stage to aging stage. Potassium decreased gradually from germinating stage to light green stage, increased gradually from light green stage to stable stage, and decreased gradually from stable stage to aging stage. The trend of calcium is opposite to that of potassium. There is no regular change of magnesium, The contents of elements are nitrogen > potassium > Calcium > magnesium and phosphorus. Zheng Jie (2007) compared the ethylene injury sensitivity of seedlings at different phenological stages of rubber trees and found that there was no significant difference in ethylene injury degree between seedlings at different phenological stages.Chen Haijian et al. (2006) showed that there were significant differences in light compensation point and light saturation point in different phenological stages of the photosynthetic characteristics of rubber seed seedlings during bud grafting. Therefore, phenology period is an important direct index for the cultivation of hevea tree seedlings, and it has obvious influence on the seedling germination, sawing, caressing and nursery.

At present, bud grafting is the main planting material of rubber tree.Cut back is an important link of rubber tree bud grafting.In this study, the phenological stage of the top leaf of rubber tree seedlings was divided into four treatments, and the sawing was carried out in the bud setting stage, bronze stage, light green stage and stable stage respectively, to observe the effect of sawing on the bud setting rate and growth potential of scion in different phenological stages.Therefore, this study has important guiding significance to improve the utilization rate of rubber seedlings, reduce the production cost of seedlings, shorten the cultivation time of seedlings, and better manage the seedlings.

II. MATERIAL AND METHODS

The experiment was carried from September 2020 to February 2022 in the protective cultivation base of natural rubber of Rubber Research Institute of Chinese Academy of Tropical Agricultural Sciences, Danzhou City, Hainan Province,China. The polybag-raised buddings of rubber tree were used as experimental materials. The GT1 seeds of rubber tree were sown in the sand bed about 20 days lather were transplanted in seedling bag (the bag caliber is 18cm, high is 35cm). The seedlings of rubber tree were incubated about one year in the bag, and then budded with scion CATAS 7-20-59, After budding successfully, they were cut back at the different leaf phenology (sprout period, leaf-unfold stage, light green leaf stage, stable leaf stage), and then transfer to greenhouse unified management. Four treatments were designed in this study, the treatment A was cut back at the leaf phenology was sprout period, the treatment B was cut back at the leaf phenology was leaf-unfold stage,the treatment C was cut back at the leaf phenology was light green leaf stage,the treatment D was cut back at the leaf phenology was stable leaf stage. Each treatment was performed with 40 polybag-raised buddings for 3 replicates. Routine water and fertilizer management and pest control were carried out during the experiment. To investigate the budding rate and nursery rate of rubber bag seedlings under different treatments. The plant height, stem diameter, leaf whorl distance and leaf number of seedling scion 1-2 of each treatment were measured. The tape measure was used to measure the plant height and leaf whorl distance of scion, and the vernier caliper was used to measure the stem diameter of scion. The experimental data were statistically analyzed by Excel2010 and DPS6.5.

III. RESULT AND DISCUSSION

Effect of cut back at the different leaf phenology on germination rate and nursery rate

There are factors that affect the budding rate and nursery rate of rubber tree. The table 1 showed that the C (97.33%) was the largest and the C(94.00%) was smallest in the budding rate, A was significantly higher than C, and there was no significance among other treatments. A (97.80%) was the largest and the C(90.00%) was smallest in the nursery rate, there was no significant difference between A and D, both of which were significantly higher than B and C, while there was no significant difference between B and C.The budding rate and nursery rate of rubber bag seedlings under different treatments have up to 90%, and the cut back in the sprout period and stable leaf stage of phenology was the most conducive to the budding and nursery of seedlings. Yu Jingjuan's (2021)study showed that when the old and young buds of reken 525, RRII105 and Yunyan 73-477 were budded, there was a significant difference in the budding rate of the scion, and the budding rate of the young buds was 10.44-17.04% higher than that of the old ones.Gui mingchun et al (2021) Showed that different cut back mode significant or extremely significant influence on the budding rate of rubber tree, it is consistent with this study. Whether the seedlings can reach the state of nursery is closely related to seedling management.

Table 1 The germination rate and nursery rate of rubber bag seedlings under different treatments

Treatment	budding rate(%)	Nursery rate(%)
A	97.33aA	97.80aA
B	94.53abA	90.20bB
C	94.00bA	90.00bB
D	96.67abA	96.60aA

Note: The lowercase letters and uppercase letters indicate significant difference at 0.05 and 0.01 levels, respectively. The same below.

Effect of cut back at the different leaf phenology on growth in the first leaf whorl

Chen et al (2018) used rootstocks of different sizes (0.5-1.2cm) to study the small tube seedlings of rubber trees, and showed that rootstocks grew better with the increase of rootstocks within a certain size range.Hu et al (2018) study also showed that scion growth of large stock was significantly or extremely significantly greater than that of medium stock and small stock.Zhou et al (2012) study showed that the rootstock variety affected the germination survival rate and scion diameter growth.The results showed that the scion growth was affected by the variety, size and quality of rubber stock.The table 2 showed that there were no significant difference in scion plant height between A, B and D, and then there were significant difference higher than C, A (37.07cm) was the highest, C (33.00cm) was the shortest. There were no significant difference in scion stem diameter between A and B, there were significant difference thicker than B and C, B and C were the smallest. The A was significant difference C on the leaf whorl distance higher than C, the C was the shortest. In this study, in the first leaf of the young seedlings, except for the weak growth of the scion at the light green stage, the good growth of the scion at the budding stage, bronze stage and stable stage was observed.The results showed that the stock cutting at different phenological stages resulted in different endogenous hormone and nutrient storage, which affected the scion growth.

Effect of cut back at the different leaf phenology on growth in the second leaf whorl

The table 3 The treatment A showed the best plant height, stem diameter, leaf whorl distance and the leaf number, while treatment C had the worst in the second leaf whorl. Plant height of A, B and D were significantly higher than that of C, A was significantly higher than that of B and D , D was significantly higher than that of C, and there was no significant difference between B and D; Stem diameter of A was significantly higher than that of B, and there was no significant difference among A and C and D; Leaf whorl

distance of A, B and D were significantly higher than that of C, A was significantly higher than that of B and D, and there was no significant difference between B and D; Leaf number of A and B were significantly higher than that of C and D, A was significantly higher than that of B, and there was no significant difference between C and D.

In the first leaf, there was no significant difference in the scion growth of the stem cut at budding stage, bronzing stage and stable stage, but in the second leaf, the scion growth of the stem cut at budding stage was more and more obvious, and the growth was significantly better than that of the stem cut at light green stage, and also significantly better than that of the seedlings cut at bronzing stage and stable stage.From the beginning of budding scion, scion growth and growth to the nursery, its performance is the best, indicating that cutting back in the sprout stage is the best.Only when the rubber tree grows to the stable stage of the second leaf can it reach the standard nursery (GB/T 17822.2-2009). The growth of the second leaf directly affects the nursery quality of the seedlings and the recovery growth rate of the seedlings when they are planted in the nursery.

Table 2 Effect of cut back at the different leaf phenology on growth in the first leaf whorl

Treatment	The first leaf whorl			
	Plant height(cm)	stem diameter(mm)	leaf whorl distance(cm)	leaf number(pieces)
A	37.04aA	6.02abA	21.53abA	9.66aA
B	36.91aA	5.91bA	22.42aA	8.95abA
C	33.00bA	5.91bA	19.38bA	8.81bA
D	35.77abA	6.17aA	21.42abA	9.48abA

Note: The lowercase letters and uppercase letters indicate significant difference at 0.05 and 0.01 levels, respectively. The same below.

Table 3 Effect of cut back at the different leaf phenology on growth in second leaf whorl

Treatment	The second leaf whorl			
	Plant height(cm)	stem diameter(mm)	Leaf whorl distance(cm)	Leaf number(pieces)
A	59.30aA	6.96aA	18.71aA	7.12aA
B	55.50bAB	6.46bA	15.57bB	6.85bB
C	50.03cC	6.59abA	12.89cC	6.56cC
D	54.57bB	6.78abA	14.96bB	6.62cC

Utilization rate of rubber tree seedlings after bud grafting

According to the phenological period of the top leaf, the production of rubber tree seedlings was directed. Under normal circumstances, rubber tree seedling seedling is in the top of the phenology stable period before cut back. In this study, sawing seedlings at the budding stage had the best growth, while there was no significant difference between the sawing seedlings at the bronze stage and the stable stage, indicating that sawing seedlings at the budding stage, bronze stage and stable stage could be carried out. This not only convenient seedling management, reduce seedling time, but also improve the utilization rate of seedlings. In the Dictionary of Rubber Tree Agriculture, Lin Weifu (2014) divided the phenological period of the top canopy of rubber tree seedlings into germinating period,

budding period, bronze period, discoloration period, light green period, stable period and old ripening period, which were more than the germinating period, discoloration period and old ripening period.Subsequent studies will analyze the nutrient composition and physiological index contents of stocks in different phenological stages, which will have guiding significance for later seedling management.

IV. CONCLUSION

In conclusion, it is most beneficial for scion growth to cut the stem during the phenological period of rubber tree at the sprout period, the budding rate, nursery rate, plant height, stem diameter, leaf whorl distance and leaf number were all the best, the second was that scion growth relatively good in the stable period of phenology, and the seedling growth was weakest in the light green period. Therefor, the rootstock of rubber tree should be cut in the sprout period and stable period, and the seedling growth is the best. It is not recommended to cut in the light green stage.

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Physical and Chemical Analysis of Fish Feed Based on Fermentation of Kelakai Leaf (*Stenochlaena palustris* (Burm.F.) Bedd)

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Abstract— *Kelakai (Stenochlaena palustris) can be used as an ingredient in fish feed because it has a high protein content. The problem with the use of kelakai for fish feed is that the crude fiber content is quite high, and the improvement of this nutritional value can be done through the fermentation process. The purpose of this study was to analyze the physical and chemical properties of fish feed based on fermented kelakai leaves. The research was conducted at the Nutrition Laboratory, Faculty of Fisheries and Marine Affairs, Lambung Mangkurat University Banjarbaru, South Kalimantan Province for ± 1.5 months. This study used a completely randomized design (CRD) with 3 treatments, namely Treatment (A) non-fermented kelakai leaf-based feed, treatment (B) fermented kelakai leaf-based feed with a dose of probiotics 5%, and Treatment (C) Fermented feed based on a 10% dose of probiotics, with test parameters namely physical test and chemical test of feed. The results showed that the longest durability of feed was destroyed after 1 hour 02 minutes in the non-fermented treatment, while the best feed buoyancy was in the treatment of kelakai leaf fermentation-based feed at a dose of 5% for 43.75 seconds. Kelakai leaf fermented feed with doses of 0%, 5%, 10% showed the value of protein content (25.78%-26.28%), crude fiber (7.67%-7.96%), fat (3.32%- 6.88%), and contains 8 essential amino acids (L-Phenylalanine, L-Leucine, L-Valine, L-Arginine, L-Lysine, L-Leucine, L-Threonine, L-Histidine) and 7 non-amino acids. essential oils (L-Serine, L-Glutamic acid, L-Alanine, glycine, L-Aspartic, L-Tyrosine, L-Proline) where the highest value was in the fermented feed based on the 5% dose of tapioca flour.*

Keywords— ***Physical analysis, proximate, amino acids, fermentation, kelakai, fish feed.***

I. INTRODUCTION

Feed is one of the important components in aquaculture activities, but the costs incurred for feed can reach 60% of production costs. An alternative that can be done is to make feed independently by utilizing local ingredients that are abundantly available and contain the right nutrients. Kelakai (Stenochlaena palustris) can be used as an ingredient in fish feed because it has a high protein content.

The results of the research by Fatmawati and Fauzana (2016), stated that the young shoots of the young kelakai leaf contained 27.31% protein compared to the old leaves of 26.79%. The constraint on the use of kalakai for fish feed is the high crude fiber content of 10.45% for young

leaves and 15.62% for old leaves (Fatmawati and Fauzana, 2016), while fish needs for crude fiber are not more than 8% (Fatmawati and Fauzana, 2016). Mujiman, 2000). It also contains vitamins and minerals which include ferrum (4153 mg/100 g), vitamin C (41 mg/100 g), protein (2.36%), beta-carotene (6.69 mg/100 g) and folic acid (1.13 mg/100 g) (Petricka, Makiyah & Mawarti, 2018).

Improvement of nutritional value can be done through the fermentation process of feed ingredients or feed using microbes or probiotics (Arief, Fitriana and Subekti, 2014). Fermentation products are generally easily biodegradable and have a higher nutritional value than the original material (Winarno, Fardiaz and Fardiaz, 1980). This is not only caused by the catabolic nature of microbes or breaks down complex components into simpler ones so that they are easier to digest, but also can synthesize several complex vitamins. Another benefit of fermentation is that food materials are more resistant to storage and can reduce the toxic compounds they contain, so that the economic value of the basic ingredients is much better (Pamungkas, 2011).

Fish feed is said to be of good quality if after being processed and made, has the appropriate shape and texture for buoyancy and good density for durability (Mujiman, 2000), and contains the nutritional and nutritional values needed by fish. Quality feed after being made must contain 20-70% protein, 15% carbohydrates, 10% fat, and 5% vitamins, water and minerals (Murtidjo, 2001).

The use of kelakai leaves as raw material for fish feed has not been widely used, so information on the use of kelakai leaves in fish feed is still limited. A study of the nutritional content of fermented kelakai leaf-based feed is very necessary to see its potential as a physically appropriate feed ingredient and has nutritional content that is suitable for use for fish.

II. RESEARCH METHODS

This research was carried out within 1.5 months starting from March to May 2022. The research was carried out at the Nutrition Laboratory, Faculty of Fisheries and Marine ULM for the manufacture of feed and physical testing of the feed. Proximate analysis was carried out at the Chemistry and Animal Feed Laboratory, Faculty of Agriculture ULM and amino acid analysis at the SIG Laboratory Bogor.

The tools and materials needed during this research are listed in Table 2.1 and Table 2.2.

Table 2.1 Tools Used

Tools	Description
Sttionery	Recording data
Oven	Drying ingredients
Flour tool	Refining ingredients
Feed mold	Print feed
Digital scale	Weighing materials
Scissors	Scissirs materials
Sieve	Sieve material
Plastic	Storing fermented feed
Label paper	Give information
Measuring cup	Observing feed buoyancy
Erlenmeyer	Observing the durability of feed
Pots and stove	Steaming ingredients
Small basin	Making feed
Jar	Storing pellet feed

Table 2.1 Materials Used

Material	Use
Kelakai Flour	Pellet feed ingredients
Bran	Pellet feed ingredients
Tapioca flour	Pellet feed ingredients
Vitamin mix	Pellet feed ingredients
Fish oil	Pellet feed ingredients
Probiotik EM4	Fermented ingredients
Molasses	Fermented material
Aquades	Mixing molasses probiotics

Research procedure

1. Preparation of the kelakai leaf flour:

-Young kelakai leaves are separated between leaves and stems.

-The kelakai leaves are then dried by drying directly in the sun or put in an oven with a maximum temperature of 60°C until the kelakai leaves are dry.

-The dried kelakai leaves are mashed using a flour, then filtered to produce fine flour.

2. Fermentation of kelakai flour:

-The kelakai flour is weighed and then poured into a tray to be stirred homogeneously with distilled water until it is in a moist condition.

kelakai flour is put in a plastic bag and steamed for 15 minutes.

EM4 probiotics are activated first by adding molasses which has been diluted with distilled water. Molasses used as much as 3% of the dose of kelakai flour, following the use of molasses in the ration in general is 3% (Widayati and Widalestari, 1996).

-Probiotic EM4 which was homogenized with molasses was added to the cooled kelakai leaf flour according to the treatment doses (0.5% and 10%).

-The homogenous kelakai leaf flour with probiotics is put in a plastic bag, tightly closed and tied and allowed to stand for 7 days at room temperature.

3. Manufacture of fermented feed based on kelakai leaves:

-The ingredients for the feed are fish meal, kelakai leaf flour, bran, tapioca vitamin mix flour and fish oil, with the following compositions Fatmawati and Fauzana (2016), namely 30% kelakai flour, 45% fish meal, 13% bran flour, flour tapioca 10%, vitamin mineral mix 1% and fish oil 1%.

-All feed ingredients that have been mixed evenly are then molded into pellets and dried under direct sunlight or in an oven at a maximum temperature of 40°C.

Experiment Design and Treatment

This research was carried out using an experimental method using a Completely Randomized Design (CRD) with 3 treatments as follows:

A : Non-fermented kelakai leaf-based feed (0% probiotic)

B : Feed based on fermented kelakai leaves with a 5% dose of probiotics

C : Fermented feed based on kelakai flour with a dose of 10% probiotics

Observation Parameter

1. Physical test (feed resistance in water and feed buoyancy). The durability of the feed in water is calculated based on the length of time the feed is destroyed after being put into the water, while the buoyancy of the feed is done by dropping the pellet into the water in a container (20cm high) followed by counting the time for the feed to touch the water until it sinks (Handajani and Widodo, 2004). 2010)
2. Chemical test, namely nutrient content based on proximate analysis which includes crude protein, crude fat, crude fiber, water content and ash content.
3. Amino Acid Content

Data analysis

Data analysis was carried out on the resistance of the feed in the water and the buoyancy of the feed starting from the normality test, diversity test, ANOVA and the mean difference test (Hanafiah, 2014). The data on the nutritional content and amino acids of the feed were analyzed in tabulated form and compared with the relevant literature.

III. RESULTS AND DISCUSSION

3.1. Feed Resistance in Water

The data from the observation of the endurance of the feed in the water can be seen in Table 3.1 Figure 3.1

Table 3.1 Average Endurance Test of Feed in Water (Hours)

Repetition	Treatment		
	A	B	C
1	1,01	0,20	0,30
2	1,01	0,25	0,29
3	1,02	0,15	0,31
4	1,05	0,30	0,32
5	1,03	0,36	0,33
Total	5,12	1,26	1,55
Average	1,02± 0,02	0,25± 0,08	0,30± 0,02

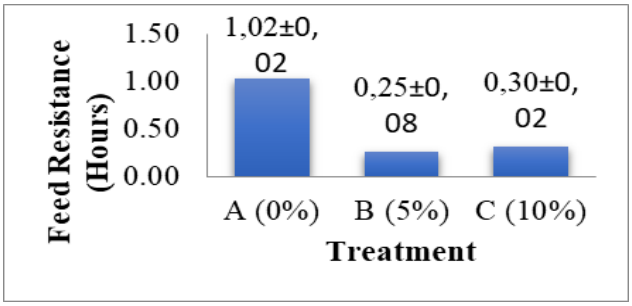

Fig.3.1 Graph of Feed Resistance Average in Water

Table and Figure 3.1. showed that the highest average feed resistance was found in treatment A (1.02 hours or 60 minutes) then treatment C (0.30 hours or 18 minutes), and the last one was treatment B (0.25 hours or 15 minutes).

The results of the Lilifors normality test and the Barlett homogeneity test on the resistance of feed in water showed Lmax (0.34) < Ltab 5% (3.49) where the data spread normally, and X2 count (0.01943) <X2 table 5% (

15,507) and X2table 1% (20,090) shows homogeneous data.

The results of the analysis of diversity (ANOVA) of feed resistance showed that Fcount > from Ftable 5% and less than Ftable 1%, so it was decided to accept H1 and reject H0 or fermented feed based on tapioca flour was significantly different to the resistance of feed in water, where the feed treatment without fermenting the leaves of anchovies, their resistance to water was better than other treatments.

Pellets made of adhesive take ± 1.05 hours to disintegrate (Krisnan and Ginting, 2009). The quality of feed is seen from the durability, at least for 10 minutes in the water (Mujimam, 2000). The fermented fermented fermented feed using EM4 can be used as an alternative feed for aquaculture activities, because of its dry, compact and not easily destroyed physical characteristics when put into water. Good quality feed can last more than 15 minutes for catfish feed, 5 minutes for carp feed, and tilapia feed for 90 hours (Utomo, 2015).

3.2. Feed Buoyancy

The data from the observation of feed buoyancy can be seen in Table 3.2 and Figure 3.2.

Table 3.2 Average Feed Buoyancy Test (Second)

Repetition	Treatment		
	A	B	C
1	12,68	41,25	32,45
2	11,19	43,35	31,12
3	10,52	45,37	34,53
4	10,10	43,52	32,68
5	11,08	45,25	38,25
Average	11,11± 0,98	43,75 ±1,68	33,81± 2,77

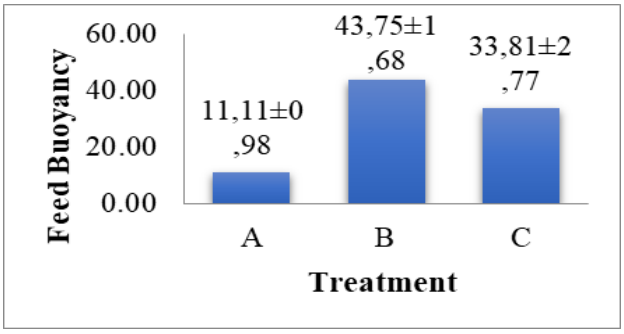

Fig.3.3 Feed Buoyancy

Table and Figure 3.2 show the highest average feed buoyancy in treatment B (43.75 seconds) followed by treatment C (33.81 seconds) and finally treatment A (11.11 seconds).

The results of the Lilifors normality test and the Barlett variance homogeneity test on feed buoyancy showed Lmax (0.35) < Ltab 5% (3.49) where the data spread normally, and X2 count (2.084) < X2table 5% (15.507) and X2table 1% (20,090) shows homogeneous data.

The results of the analysis of diversity (ANOVA) of feed buoyancy showed that Fcount (366,762) > Ftable 5% (3.89) and Ftable 1% (6.93), so it was decided to reject H0 and accept H1 or fermented feed based on tapioca flour. feed float in water. Fermented feed based on malaya leaves with 5% probiotics is the best treatment for feed buoyancy.

Feed made from fermented kelakai flour using probiotic EM4 needs additional treatment because in the process of making feed it does not use a feed making machine that is capable of floating (extruder) so that the feed sinks quickly and this feed can be given to catfish and shrimp (Afrianto and Liviawaty). , 2005). The pellet category is physically good, that is, it has a high quantity of water stability and density, is impact resistant, but has a medium water absorption capacity and a low expansion ratio (Krisnan and Ginting, 2009). In certain circumstances, pelleted feed only needs to float a few minutes before being eaten by fish (Handajani and Widodo, 2010).

3.3. Feed Nutrient Content

3.3.1. Proximate Analysis Results

The data from the proximate analysis of pellet feed based on the fermentation of macaque leaves can be seen in Table 3.3. following :

Table 3.3. Yield Nutritional Content of Feed (%)

Parameters	Treatment		
	A	B	C
Water	4,39	12,66	13,28
Ash	10,25	11,75	12,12
Crude Protein	25,78	25,78	26,28
Coarse Fiber	7,96	7,96	7,67
Crude Fat	6,88	3,32	4,98

1. Moisture Content

According to Winarno (2015) the water content in the feed indicates the freshness and durability of the feed. The value of the water content of the feed in this study was between 4.39%-13.28% which was still within the tolerance limit for fish growth, where 70%-90% of the wet

weight was the water content in fish food (Mujiman, 2000).

2. Ash content

According to Irawati (2008) to determine whether the feed is good or not, selecting synthetic and native feeds, a calculation of the ash content of the feed is carried out which is a parameter of a material. The results of the proximate analysis of feed ash content in this study ranged from 10.25%-12.12%, this range was still within the tolerance limit for fish growth.

Ash content cannot describe the appearance and amount of minerals contained in the feed. The higher the ash content, the lower the quality of the feed (Suparjo, 2010). The maximum ash content in fish feed is 15% (Mujiman, 2000).

3. Crude Protein

The results of the crude protein value of pellet feed based on fermented macaque leaves in this study were between 25.78%-26.28% According to Mujiman (2000), the amount of protein ranged between 20%-60% needed by fish in a feed, and 30-36 % is the optimum protein requirement. Fish will not improve if the protein quality is less than 6% wet weight which is controlled by its amino acid content.

4. Coarse Fiber

According to Suparjo (2010) crude fiber is partly derived from plant cell walls which contain plant components. Crude fiber is a variety of fibers that are not easily crushed. The results of crude fiber feed in this study ranged from 7.67%-7.96%, this range was sufficient for fish growth. The function of fiber is to facilitate the digestive process and does not have growth substances (Nonok and Fitazar, 2011).

5. Fat

Sources of stamina, essential fatty acids, phospholipids, sterols and an introduction to the process of absorbing vitamins mixed in are the benefits of fat (Murtidjo, 2001).

The results of the crude fat content of the feed in this study ranged from 4.98 - 6.88, this range was still within the tolerance limit for fish growth. According to Mujiman (2000), the need for fat in fish feed ranges from 4-18%.

3.3.2. Amino Acid Content

Table 3.4 shows that the plant based diet contains 8 essential amino acids, namely phenylalanine, leucine, valine, arginine, lysine, leucine, L-Threonine, histidine and 7 non-essential amino acids, namely serine, glutamic acid, L-Alanine, glycine, aspartate. , tyrosine, proline.

Table 3.4. Feed Amino Acid Content

Amino Acid(%)	Treatment		
	A	B	C
L-Serine	0,61	0,90	0,69
L-Glutamic Acid	1,54	2,40	1,65
L-Phenylalanine	0,53	0,76	0,59
L-Isoleucine	0,49	0,83	0,55
L-Valine	0,71	1,07	0,76
L-Alanine	0,79	1,19	0,85
L-Arginine	0,62	0,87	0,64
Glycine	0,68	1,09	0,80
L-Lysine	0,67	1,19	0,70
L-Aspartic Acid	1,14	1,69	1,18
L-Leucine	0,93	1,46	0,98
L-Tyrosine	0,25	0,36	0,28
L-Proline	0,55	0,79	0,60
L-Threonine	0,59	0,88	0,65
L-Histidine	0,22	0,37	0,27

Source : SIG Labotratory Bogor 2022

The highest amino acid value in treatment B was followed by treatment C, then the lowest was treatment A. The results of the analysis showed that the fermented feed of kelakai flour contained amino acids that met the needs of fish, where the content of L-Glutamic acid, one of 15 amino acids, had the highest value in treatment B. of (2.40%).

The amino acid compositions are shown in Table 3.4 and the overall results for the compositions of treatments A, B, and C show varying values. The top amino acids from the feed test results include L-Glutamic acid, L-Aspartic, L-Leucine, lysine and valine,

Protein quality is related to the amino acid profile it contains. Amino acids are classified according to the body's ability to synthesize and their metabolic needs. This classification is known as essential and non-essential amino acids. Most animals including fish require 10 amino acids, namely arginine, histidine, isoleucine, leucine, lysine, methionine, phenyl alanine, threonine, tryptophan and valine (NRC, 1993). The need for essential amino acids in ornamental fish such as goldfish ranges from 3.4% to 11.8% (Fiogbe & Kestemont 1995) higher than consumption fish such as Japanese eel (Anguilla japonica), carp (Cyprinus carpio), catfish (Ictalurus punctatus) and

salmon (Oncorhynchus tshawytscha) which only ranged from 0.5% to 6.0% (NRC 1993).

Lysine is one of the ten essential amino acids that can be used as a reference amino acid, there are several reasons to choose lysine as a reference amino acid. First, a major function of lysine in the animal body is the deposition of protein tissues, since its requirements are not affected by other metabolic roles. Second, depending on the fish species and the type of feedstock, lysine usually has a major role in limiting amino acids because it is known that the need for lysine is much greater than for other amino acids (Miles & Chapman 2007).

The need for the essential amino acid lysine for the body of fish is between 4-6% of the ration protein (Agustono, Widodo and Paramita, 2010). According to FAO (2014) the lysine requirement of omnivore fish is 2.07%.

The optimal lysine amino acid content in feed for the growth of sunu grouper fry is 2.84% (Giri et al, 2009). The feed in this study contained the highest lysine at 1.19% which was still equivalent to the lysine content in general commercial feed. Commercial feed currently available has a lysine content of 1.41% (Khalida, Agustono and Paramita, 2017).

Cowey & Tacon (1983) suggested that the amino acid requirement for fish is essential and should be linked or even regulated by the pattern of amino acid presence in muscle tissue. Imbalance of the amino acid profile in the diet can reduce food intake and reduce the efficiency of utilization of essential amino acids.

IV. CONCLUSION

Physical properties of fermented kelakai flour feed with a dose of 0%, 5%, 10% seen from the durability of the feed in water, the highest dose of 0% of the feed was destroyed after 1 hour 02 minutes, while the best feed buoyancy was in the treatment of fermented kelakai-based feed with a dose of 5 % with a value of 43.75 seconds.

Chemical properties of fermented kelakai flour feed with a dose of 0%, 5%, 10% showed the value of protein content (25.78%-26.28%), crude fiber (7.67%-7.96%), fat (3.32 %-6,88%), and contains 8 essential amino acids (L-Phenylalanine, L-Leucine, L-Valine, L-Arginine, L-Lysine, L-Leucine, L-Threonine, L-Histidine) and 7 fatty acids non-essential amino acids (L-Serine, L-Glutamic acid, L-Alanine, glycine, L-Aspartic, L-Tyrosine, L-Proline) where the highest value was in fermented feed based on the dose of 5% tapioca flour.

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V. GRATITUDE

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Amount Stock of Blue Carbon in Mangrove on the Area of Pt Arutmin Indonesia Kintap Mine Mekarsari Village, Tanah Laut Regency, South Kalimantan

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Abstract— *Mekarsari Village is located in the Kintap sub-district, Tanah Laut district, South Kalimantan Province, which is an area that has a 1.83 ha mangrove ecosystem. Mangrove ecosystem is one form of forest ecosystem that is unique and distinctive, found in tidal areas of coastal areas, beaches, and several small islands. In addition to the mangrove ecosystem, there is also a coral reef ecosystem with the condition of coral reefs around the marine waters of Kintap District ranging from low to moderate based on coral reef assessment criteria according to the Indonesian Environment Ministerial Decree, No. 4/2011, (Tony. F, et al 2021). The purpose of this study was to determine the amount of biomass and the amount of blue carbon stock in the mangrove ecosystem in Mekarsari Village. Data was collected by plotting the area and taking the upper sample to determine the amount of blue carbon stock through the results of laboratory analysis. The results of the study based on data collection in the field, namely the mangrove ecosystem in Mekarsari Village has a total biomass value of 98.52 tons/ha and the total amount of blue carbon stock is 84.72 tons C/ha.*

Keywords— ***Mekarsari Village, Mangrove, Biomass, Blue Carbon Stock.***

I. INTRODUCTION

PT Arutmin Indonesia Kintap Mine Area is a company operating in the coal mining industry located in Mekarsari Village, Tanah Laut Regency, South Kalimantan Province. In the company's activity area, there is a mangrove ecosystem which has an area of 1.83 ha, it is known that before the existence of mangroves this place was a community shrimp pond that had been converted into mangroves in 2014. Presidential Regulation of the Republic of Indonesia number 73 of 2012 concerning the national strategy for managing mangrove ecosystems it is necessary to use the conservation of mangrove ecosystems.

The South Kalimantan Mangrove Ecosystem covers an area of 67,008,659 hectares of mangrove forest in the coastal area of South Kalimantan (South Kalimantan DKP, 2018). Based on data from the One Map Policy (KSP) or the One Map Policy (OMP) 2016, South Kalimantan has a mangrove area of only 55,556.13 ha. According to

Baharuddin (2020), the coastal area of South Kalimantan is a coastal ecosystem, especially the mangrove ecosystem. This is due to the many activities carried out in the area. For example the construction of public and special ports, cultivation of mangrove land, plantations, agriculture, industry and conversion into settlements.

The mangrove ecosystem is one of the potential parameters to determine the presence of blue carbon stocks. The role of mangroves in blue carbon is more emphasized as an effort to use CO2 in the photosynthesis process and store it in biomass and sediments to mitigate climate change. The existence of the mangrove ecosystem provides benefits, among others, for coastal water ecosystems as a place for foraging for food, spawning grounds and animal husbandry. Rapid developments have a negative impact on the environment, including the conversion of mangrove forests into ponds and tourist destinations, as well as the disposal of organic waste into coastal waters.

Based on the above that the mangrove ecosystem is one of the ecosystems that is rich in benefits and functions from an ecological, biological and economic perspective, therefore it is necessary to conduct research related to blue carbon stock estimation and vegetation analysis in mangroves in the PT Arutmin Indonesia area. Kintap Mine, Mekarsari Village, Tanah Laut Regency, South Kalimantan Province.

II. RESEARCH METHODS

TIME AND LOCATION

The mangrove blue carbon stock study was carried out in March-April 2022. The research location was in the area of PT Arutmin Indonesia Tambang Kintap, Mekarsari Village, Tanah Laut Regency, South Kalimantan Province.

DATA ACQUISITION METHOD

DETERMINING THE SAMPLING LOCATION

Determination of the location of field data collection based on the research location of PT Arutmin Indonesia Kintap Mine for company data purposes, because at that location there is no research related to the mangrove ecosystem so that the company can achieve the specified target. At station 1 with coordinates 3° 52' 39.78" S 115° 19' 41.86" it has the characteristics of more types of mangroves found in the location because it is close to the sea, the ecosystem condition at station 1 is better in terms of substrate and mangrove growth. . At Station 2 with coordinates 3° 52' 35.25" S 115° 19' 43.17", the density level and the types of species found at the location and the condition of the substrate are mud mixed with sand are lower. Then at station 3 with coordinates 3° 52' 33.75" S 115° 19' 41.36" E, the condition is more dominating than station 2, the density level is also higher.

SAMPLING PROCEDURE

The sampling is use stratified systematic sampling, meaning that the entire part of the mangrove ecosystem will be utilized as much as possible, the part that is predicted to be able to absorb carbon using concepts that are in accordance with the IPCC (Intergovernmental Panel on Climate Change) 2003. sampling as many as 3 stations and at each station took 3 sampling to take the upper biomass consisting of leaves, twigs, stems, main stem.

In the production of mangrove biomass, it can be seen from the measurement of trunk diameter, tree density, and tree age (Darusman, 2006). To determine a biomass, that is by selecting a minimum of 30 trees for sampling in each plot area. All stands in the plots were taken, but only leaves, twigs, and branches to determine their wet weight were weighed at the observation site. Sub samples were taken weighing 100 grams of each tree that had been sampled. In order to obtain constant sampling results, the sampling process was carried out in an oven at a temperature of 80oC for ± 24 hours.

Biomass Measurement Procedure

Aboveground

Aboveground or above-ground biomass, and the used parameters are leaves, twigs, branches and also the main stem. It is these parts that make a major contribution to the calculation of biomass and carbon stocks in primary (land) forests. All data from the four will be aboveground data and then further analyzed to obtain predictions of stored carbon content

Tree Volume

Tree Volume Analysis of the data in this study is to calculate the biomass based on the volume of the tree without calculating the canopy (branches, leaves, flowers and fruit) using the equation of Heriyanto et al. (2012) as follows:

$$V = 1/4.\ \pi.d^2\ .t.f$$

Description:

V : Tree Volume (cm3)

π : 3,14

d : Tree diameter (cm)

t : Total height (cm)

Wood Density Measurement

The density of wood is measured by weighing the wet weight of the wood sample that has been taken. After weighing the wet weight, the wood sample was then placed in an oven at 100°C for ±48 hours. Furthermore, the

samples that have been put in the oven are weighed dry (Hairiah et al., 2011). Irregular volume measurement can be done by inserting the object into a measuring cup filled with water. The volume of the object can be known from the change in the volume of water that is read in the measuring cup or by using the formula:

Object Volume (ml) = Final volume (ml) - Initial volume (ml)

According to Hairiah et al. (2011), the density of wood can be calculated by the formula:

Density (g/cm^3) = dry weight (g)/volume (cm^3)

Biomassa

The amount of biomass was obtained from the results of measuring the volume of trees and measuring the density of wood. According to Bismark et al (2008) the formula used to calculate biomass is as follows:

B = V x

Description:

B : Biomass (kg)

V : Tree volume (m^3)

Blue Carbon Stock

The next step is to calculate or measure the carbon content of parts of the mangrove ecosystem with known biomass. It includes three main parts, namely carbon accounting from aboveground biomass.

Cb = B x % C organic

Description:

Cb : Combined carbon and biomass (kg)

B : Total biomass (kg)

% C organic : 0.47 resulting from the measurement of the results of laboratory analysis

- This formula can be used to calculate individual or total biomass from aboveground and belowground, so it will be possible to know the contribution of each part (leaves, twigs, branches, main stem, main roots and also branch roots).

- Regarding organic % C, because this activity did not calculate the organic % C content in the laboratory, it was agreed to use a value of 0.47 as a constant.

III. RESULTS AND DISCUSSION

Biomass Content

The calculation of above-ground biomass includes the main stem, twigs, branches, and leaves. Field sampling showed that no branches were found because the entire sample tree experienced branching of the main trunk at a height of less than 1.3 m (DBH limit). In the context of vegetation analysis, this condition refers to the technical calculation of DBH and it is stated that the 'branches' still include the main stem. Therefore, as a result, the definition of a branch which is a branch of a branch is considered a 'branch'. However, in technical calculations, aboveground biomass is still considered as a twig, and branches on the main stem before a height of 1.3 m are considered as part of the main stem.

Tree Volume

Volume can be calculated which can then be used for biomass calculations using variables such as density, tree diameter, tree height which can be seen in table 1.

Table 1. Tree Volume per Station

Station	Type	Average Diameter (cm)	Height (m)	Volume (m^3/ha)
1	*Avicenia alba*	5.96	6.4	3.76
	Rhizophora mucronata	6.55	6.71	3.32
	Sonneratia alba	9.55	8.57	9.70
	Total	7.35	7.23	16.78
2	*Rhizophora mucronata*	7.76	5.37	14.69
	Avicenia alba	6.05	6.5	0.77
	Total	6.91	5.93	15.46
3	*Avicenia alba*	5.77	5.70	5.67
	Rhizophora mucronata	8.60	5.07	10.98
	Total	7.19	5.38	16.65

(*Source : Primary Data 2022)*

From the calculation of the average diameter and height of mangrove stands can be determined volume. At station 1 the total volume is 16.78 m3/ha which is the highest volume, at station 2 is 15.46 m3/ha, and at station 3 16.65 m3/ha. According to Bismark et al (2008) the factors that affect the volume are tree diameter, tree height, density level, and age of mangrove trees.

Wood Density

The density of wood can be seen or known by taking wood samples directly, then the samples are dried using an oven at 80oC for 48 hours and the dry weight can be determined by weighing the dried samples. The results of the analysis of the density of wood can be seen in Table 2. below:

Table 2. Wood Density

No	Type	Dry Weight (g)	Vol (ml)	Density (g/ml)	Density (kg/l)
1	*Avicenia alba*	4.7	8	0.588	588
2	*Avicenia alba*	5	6	0.833	833
3	*Avicenia alba*	6.2	8	0.775	775
		Average Density		0.730	730
4	*Rhizophora mucronata*	4.8	5	0.960	960
5	*Rhizophora mucronata*	5.2	7	0.743	743
6	*Rhizophora mucronata*	6.3	8	0.788	788
		Average Density		0.830	830
7	*Sonneratia alba*	5.2	8	0.650	650
8	*Sonneratia alba*	5.8	9	0.644	644
9	*Sonneratia alba*	6.5	11	0.591	591
		Average Density		0.630	630

(Source : Primary Data 2022)

The results of laboratory research showed that the density of wood of the Avicenia alba species was 730 kg/l, then the density of Rhizopora mucronata was 830 kg/l, and the density of Sonneratia alba was 630 kg/l. The difference between the results of laboratory analysis and previous research is thought to be due to differences in the place or geographic location of sampling. According to Marsoem et al (2014) that can cause the effect of value on wood density is tree age, tree diameter circumference, soil fertility.

Biomass Estimation

Biomass is the total amount of living matter above the surface of each tree species in tons of dry weight per unit area. Estimation or estimation of biomass can be done after knowing the volume of trees and wood density at each observation station. Further biomass estimation can be seen in Table 3. below:

Table 3. Biomass Estimation

No	Type	Leaf Biomass (ton/ha)	Twig Biomass (ton/ha)	Branch Biomass (ton/ha)	Stem Biomass (ton/ha)	Biomass Total (ton/ha)
1	*Avicennia alba*	4.87	12.12	21.93	6.83	45.75
2	*Rhizopora mucronata*	2.56	5.90	10.13	24.06	42.64
3	*Soneratia alba*	0.44	1.48	2.10	6.11	10.13
Total (ton/ha)		7.86	19.49	34.16	37	98.52

(Source : Primary Data 2022)

If depicted in a bar graph is shown as follows, then each type can be known the contribution of its biomass in more detail. Trunk is the highest biomass compared to other structures, this is because there are differences in wet weight and dry weight which greatly affect the amount of biomass in the mangrove ecosystem. Differences in the amount of biomass in tree species along with the addition of tree age and density. Density or stands is a factor that can affect trees because of competition for sunlight which is used in the photosynthesis mechanism.

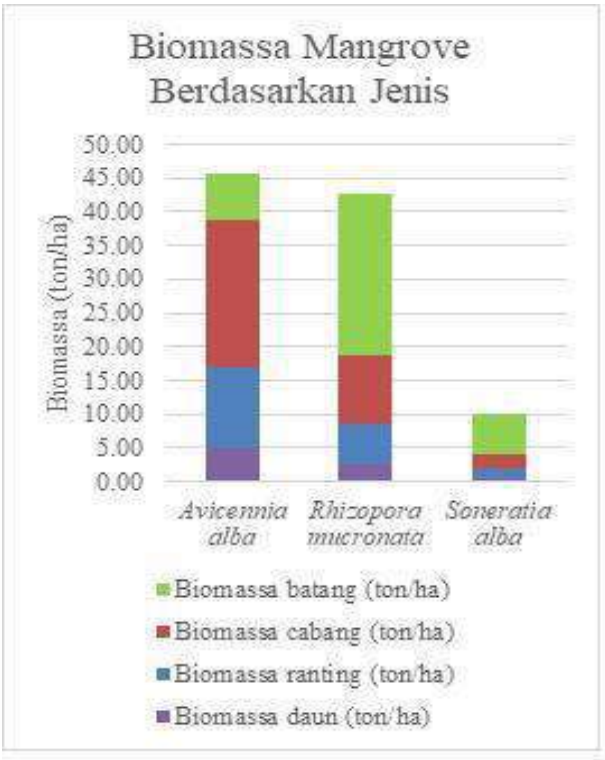

Fig. 1: Mangrove Biomass Bar Chart by Type (ton/ha)

Shows that Avicennia alba has the largest biomass in contributing to the mangrove ecosystem in Mekarsari Village, then Rhizopora mucronata contributes quite a lot, and Sonneratia alba is a species that contributes lower than other species. While the plant organs that contributed the highest biomass were stems, branches, twigs, and leaves.

Blue Carbon Stock

Blue carbon stock is carbon found in marine and coastal ecosystems, one of which is found in mangrove ecosystems. The mangrove ecosystem is a plant that absorbs carbon from the air to carry out the photosynthesis process, the carbon is stored in the structure of the mangrove tree where the most storage is in the trunk, branches, and in the soil substrate. The larger the diameter of the stem of a species, the more it can store the blue carbon stock. The blue carbon stock in Mekarsari Village can be seen in Table 4. Below

Table 4. Blue Carbon Stock by Station

Station	Type	Biomass (ton/ha)	Carbon (ton/ha)
1	*Avicenia alba*	16.66	7.83
	Rhizophora mucronata	5.07	2.38
	Sonneratia alba	10.13	4.76
	Total	**31.85**	**14.97**
2	*Rhizophora mucronata*	21.73	10.21
	Avicenia alba	11.56	5.43
	Total	**33.29**	**15.65**
3	*Avicenia alba*	17.53	8.24
	Rhizophora mucronata	15.85	7.45
	Total	**33.38**	**15.69**
	Total Ton (C/ha)		46.30

(Source : Primary Data 2022)

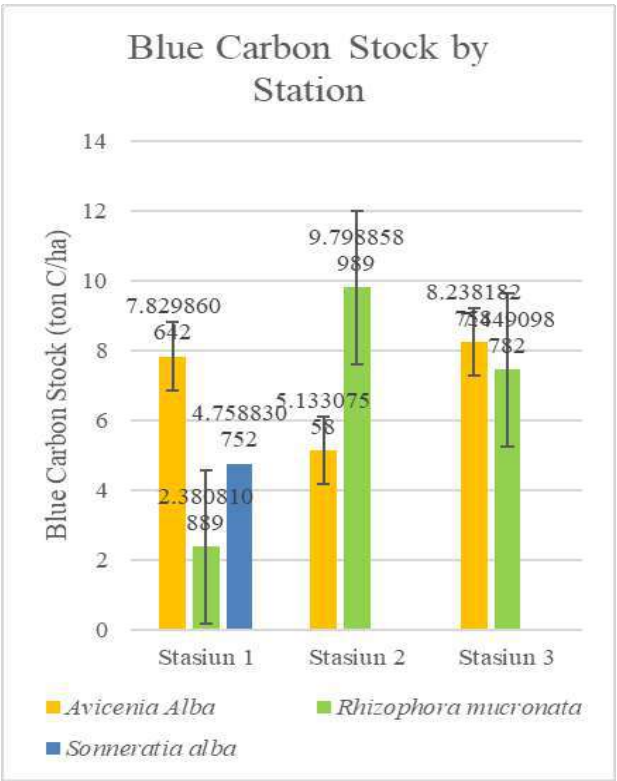

Fig. 2: Blue Carbon Stock by Station

It can be seen in table 4 above that the carbon potential at each level of vegetation on its biomass. According to (Rachmawati, et al. 2014) at the top of the surface the amount of carbon content depends on the amount of total biomass. The greater the biomass, the greater the potential for trees to store carbon. Based on the research conducted, it was found that the potential for biomass content in the mangrove ecosystem in Mekarsari Village with the results of the blue carbon stock estimation analysis showed that

the carbon stock at station 1 was 14.97 tons/ha, then at station 2 was 15.65 tons/ha, and at station 3 is 15.69 tons/ha.

Table 5. Blue Carbon Stock by Type

No	Type	Leaf Carbon (ton C/ha)	Twig Carbon (ton C/ha)	Branch Carbon (ton C/ha)	Stem Carbon (ton C/ha)	Total Carbon (ton C/ha)
1	*Avicennia alba*	2.29	5.70	10.31	3.21	21.50
2	*Rhizopora mucronata*	1.20	2.77	4.11	11.31	19.39
3	*Soneratia alba*	0.21	0.69	0.99	2.87	4.76
			Total			**46.30**

(Source : Primary Data 2022)

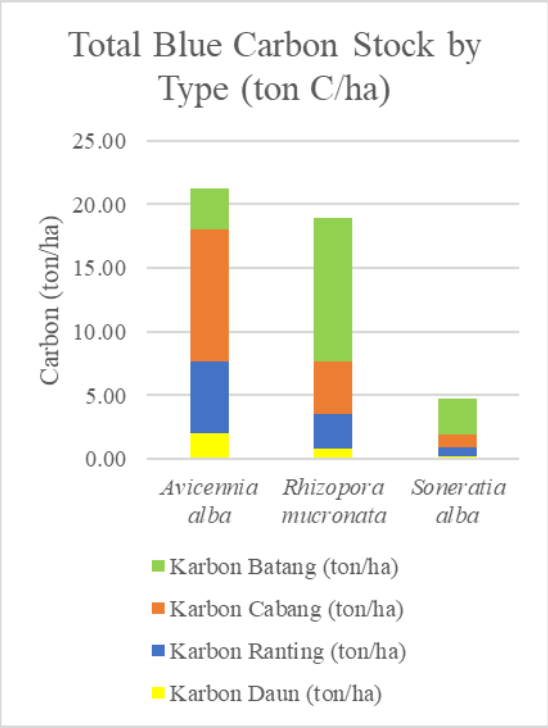

Fig.3: Blue carbon stock bar chart

Based on Table 5. the value of blue carbon stock in mangroves in Mekarsari Village, Tanah Laut Regency for Avicenia alba species is 21.50 tons C/ha, then for Rhizopora mucronata is 19.39 tons C/ha, and for Sonneratia alba is 4.76 tons C/ha. When compared with the results of Ananda Fitrian Anshary's research (2020), the value of carbon storage owned by Rhizopora mucronata in Bunati Village, Tanah Bumbu Regency has a carbon value of 370.32 tons C/ha. Therefore, the size of carbon storage in a vegetation is thought to depend on the amount of biomass contained in trees, soil fertility and the absorption capacity of the vegetation. It can be seen that there are differences in the number of 6 stations, and 81.17 ha in the mangrove area, and the sampling is done.

Amount of Blue Carbon Stock in Mekarsari Village

Table 6. Blue Carbon Stock Quantity in Mekarsari Village

Mangrove Area	Amount of Blue Carbon Stock	Total Carbon Store (ton C)
1,83 Ha	46.30	84,72

(Source : Primary Data 2022)

It can be seen from the data above, for the same type of prediction the amount of carbon stock can be different. This shows that the carbon stock is influenced by many things, including the amount that varies in each different location. This condition can be caused by limiting factors such as temperature and rainfall (Ariani, et al., 2016). In addition, it is suspected that temperature and water quality are factors that can cause differences in the amount of biomass and blue carbon stock deposits.

This study also provides information about the contribution of the mangrove ecosystem which can store CO2 emissions in the air in order to reduce the level of pollution that makes the atmosphere layer thicker. Therefore, the mangrove ecosystem can reduce or minimize global warming.

IV. CONCLUSION

The total value of biomass in the mangrove ecosystem in Mekarsari Village, Tanah Laut Regency based on the analysis results is 98.52 tons/ha. The total estimated amount of blue carbon stock in Mekarsari Village is 84.72 tons C/ha.

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Market gardening and the Economy of Urban and Peri-urban Households in the city of Dakar: Case of the Municipalities of Hann-Bel-Air, Parcelles Assainies, Ouakam and Grand-Yoff

Maraîchage et Economie des Ménages Urbains et Périurbains de la Région de Dakar: Cas des Communes de Hann-Bel-Air, Parcelles Assainies, Ouakam et de Grand-Yoff

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Abstract— *The strong urbanization of the Dakar region and its induced effects (lack of cultivation areas, floods, etc.) pose significant challenges in terms of local food security for populations. In this context, the reflection on the food and/or commercial function of the Urban and Peri-urban Agriculture (AUP) of Dakar finds all its relevance. This study focused on the issue of access to production land and the essentially commercial dimension of market gardening, making it possible to generate income likely to improve the living conditions of agri-urban households. She is interested in this particular aspect of the market gardening activity practiced in the Dakar region in four market gardening production areas (Ouakam, Parcelles Assainies, Grand-Yoff and Hann-Bel-Air) involving 120 market gardening actors. The results obtained reveal that market gardening, by table crops, raises the question of local development based on gender. Worn mainly by women, it is a commercial activity in its own right, the monetary income of which is far greater than the minimum wage in Senegal. It turns out that this almost exclusively commercial orientation indisputably allows women to better cover their food and non-food expenses inherent to life in an urban environment. However, market gardeners face problems such as the current health crisis (COVID-19), lack of water, land pressure, proliferation of pests and lack of training on cultivation techniques. Therefore, it is urgent, on the part of the competent authorities and technical and financial partners, to meet these challenges in order to strengthen the means of resilience or adaptation of agri-urban households to food and nutritional insecurity.*

***Keywords*— Table-top agriculture; Agri-urban; Peri-urban municipalities of Dakar; Household economics; Market gardening**

Résumé— *La forte urbanisation de la région de Dakar et ses effets induits (manque d'espaces de cultures, inondations…) posent d'importants défis en matière de sécurité alimentaire de proximité des populations. Dans ce contexte, la réflexion sur la fonction alimentaire et/ou commerciale de l'Agriculture Urbaine et Périurbaine (AUP) de Dakar trouve toute sa pertinence. Cette étude a porté sur la problématique de l'accès aux terres de production et la dimension essentiellement commerciale du maraîchage, permettant de générer des revenus susceptibles d'améliorer les conditions de vie des ménages agri-urbains. Elle s'intéresse à cet aspect particulier de l'activité maraîchère pratiquée dans la région de Dakar dans quatre zones de production maraîchère (Ouakam, Parcelles Assainies, Grand-Yoff et Hann-Bel-Air) impliquant 120 acteurs/actrices du maraîchage. Les résultats obtenus révèlent que le maraîchage, par cultures sur table, soulève la question du développement local adossé sur le genre. Porté majoritairement par les femmes, il constitue une activité commerciale à part entière dont les revenus monétaires sont de loin plus importants que le salaire minimum au Sénégal. Il s'avère que cette orientation presque exclusivement commerciale permet indiscutablement aux femmes de mieux couvrir leurs dépenses alimentaires et non-alimentaires inhérentes à la vie en milieu urbain. Cependant, les maraichères sont confrontées à des problèmes tels que la crise sanitaire actuelle (COVID-19), le manque d'eau, la pression foncière, la prolifération des ravageurs et le manque de formation sur les techniques culturales. Dès lors, il urge, de la part des autorités compétentes et des partenaires techniques et financiers, de relever ces défis pour renforcer les moyens de résilience ou d'adaptation des ménages agri-urbains à l'insécurité alimentaire et nutritionnelle.*

***Mots clés*— Agriculture sur table ; Agri-urbain ; Communes périurbaines de Dakar ; Economie des ménages ; Maraîchage**

I. INTRODUCTION

Le Sénégal est un pays sahélien où l'agriculture occupe une place importante dans l'économie. Le secteur agricole occupe plus de 60% de la population active et contribue à hauteur de 9,4% du PIB national et de 62,8% de la valeur ajoutée (en terme nominal) du secteur primaire (ANSD, 2020 p.3). Il est considéré comme le moteur de l'économie dans le volet agricole du Plan Sénégal Emergent (PSE), opérationnalisé par le Programme d'Accélération de la Cadence de l'Agriculture Sénégalaise (PRACAS). Ce dernier vise l'atteinte à moyen terme de la sécurité alimentaire et nutritionnelle à partir des produits prioritaires (riz, arachide, coton, etc.) qui sont des cultures d'exportation à haut potentiel de développement et à haute valeur ajoutée. Mais, cette option portée sur les cultures d'exportation a induit des conséquences considérables sur les cultures vivrières (mil, sorgho, maïs…) et pose maintenant un problème de l'autosuffisance. En effet, le Sénégal n'arrive plus à couvrir l'essentiel de ses besoins alimentaires du fait de la faible production, du manque de soutien et d'encadrement technique et des difficultés d'accès à la terre et aux ressources financières, en particulier pour les femmes et les jeunes. De plus, l'urbanisation rapide place Dakar, comme tout le pays, en situation de dépendance alimentaire vis-à-vis des pays européens, asiatiques et d'Amérique Latine.

Pour couvrir ses besoins alimentaires, le Sénégal est obligé d'importer les denrées de première nécessité (riz, sucre, lait). Ce contexte de pauvreté et d'insécurité alimentaire est accentué par la crise sanitaire de la COVID 19 – la dégradation des écosystèmes – conséquences des activités humaines (mal gouvernance, urbanisation incontrôlée, déforestation/déboisement…) et de l'irrégularité pluviométrique – qui favorisent l'exode des jeunes vers des contrées plus « fertiles », les centres régionaux, l'Europe… Ces nouveaux arrivants, sans formation qualifiante, tentent de s'intégrer dans le secteur informel (vendeurs ambulants, laveurs de voiture, cireurs, travailleurs domestiques, lingères, restauratrices de rue, etc.) ou viennent gonfler le nombre des chômeurs. Cela explique la surpopulation de Dakar ainsi que l'exode des jeunes en dehors du pays.

Malgré ces contraintes, de nombreuses initiatives, portées majoritairement par les femmes, se développent pour faire face à l'insécurité alimentaire et accroître leur autonomie socio-économique. Il s'agit de l'Agriculture Urbaine et Périurbaine (AUP) à travers le maraîchage, la transformation de produits agricoles et le recours à la restauration de rue (Ba, 2008 ; Ndoye, 2001). Ainsi, l'AUP est pratiquée dans des cuvettes maraîchères par les ménages des localités établies dans les Niayes de la région de Dakar. Une agriculture de type familial et mixte, associant cultures vivrières pour l'autoconsommation des

ménages et commerciales à destination des marchés de consommation. Une agriculture surtout caractérisée par des exploitations de petite taille, une main d'œuvre essentiellement familiale et qui se distingue aussi par ses faibles performances du fait d'un accès limité aux facteurs de production, et très souvent, aux marchés (FAO, 2011 ; ENDA GRAF SAHEL, 2013, 2019 ; Ba et Cantoreggi 2018). L'une des caractéristiques de ces exploitations agricoles familiales est également, leur extrême fragilité liée surtout aux contraintes structurelles précédemment évoquées, mais aggravées davantage par les déséquilibres manifestes liés aux phénomènes du changement climatique.

L'AUP des Niayes fait face à l'urbanisation galopante qui réduit considérablement les espaces agricoles, réduisant les quantités de productions, exposant des millions de personnes à l'insécurité alimentaire et nutritionnelle. De ce fait, une meilleure connaissance de cette forme d'agriculture, sa redynamisation et la connexion des acteurs des chaines de valeurs (transformatrices, restauratrices…) sont plus que jamais nécessaires pour booster son intégration dans le tissu urbain et le développement socio-économique et, ainsi, contribuer à relever l'un des défis majeurs des Objectifs de Développement Durable (ODD) et du Plan Sénégal Emergent (PSE) à savoir assurer une autosuffisance alimentaire saine. Le présent article tente de mieux documenter la pratique de l'AUP dans les Communes de Grand-Yoff, Ouakam, Parcelles Assainies et Hann-Bel-Air et d'éclairer sa contribution économique à la satisfaction des besoins des ménages agri-urbains. Une première partie détaille les principales caractéristiques de l'AUP dans ces communes périurbaines de Dakar. Une deuxième partie présente un bilan socioéconomique et discute de l'hypothèse d'une vocation essentiellement commerciale de cette activité, dont les recettes permettent aux ménages agri-urbains de mieux répondre à leurs différents besoins non-alimentaires, tout en contribuant au renforcement de la sécurité alimentaire par une agriculture de proximité. La dernière partie traite des contraintes qui pèsent sur le devenir de l'AUP dans ces Communes.

II. PRESENTATION DES COMMUNES DE L'ETUDE

Les Communes concernées par l'étude sont au nombre de quatre (4) : Ouakam, Hann-Bel-Air, Grand-Yoff, et Parcelles Assainies, toutes localisées dans le Département de Dakar. Située à l'Ouest de la presqu'île du Cap-Vert, la Commune de Ouakam couvre une superficie de 6,83 km^2. Les Communes de Hann-Bel-Air (10,5 km^2), Grand-Yoff (6,3 km^2) et Parcelles Assainies (3,5 km^2) sont localisées respectivement au Sud-Est, au Centre et au Nord de Dakar.

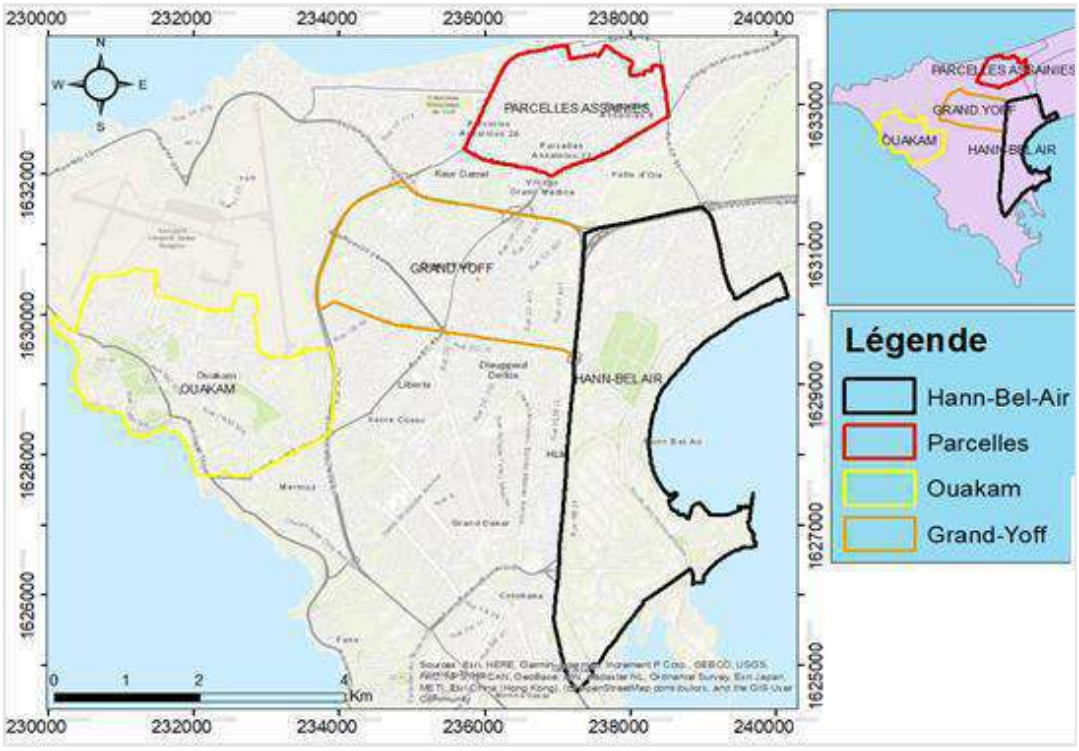

Fig.1. Carte de localisation des Communes cibles (Source : THIAW et al. 2021)

1.1. Contexte Physique et Climatique

1.1.1. Contexte Physique

Les communes de Hann-Bel-Air, Parcelles Assainies, Grand-Yoff, et Ouakam se situent dans la zone éco-géographique des Niayes de la région de Dakar. Cette zone se caractérise par des dépressions inter-dunaires dans lesquelles affleure la nappe phréatique des sables quaternaires (Diop, 2006 ; Dasylva et Cosandey, 2010 ; Ndao, 2012). Cette spécificité fait des Niayes des milieux atypiques de la région sahélienne (Dasylva et Cosandey, 2010). La nappe phréatique, dite « nappe de Thiaroye », s'étend tout au long du littoral depuis Thiaroye jusqu'à Saint-Louis sur une dizaine de kilomètres de largeur (Chaoui, 1996). Elle repose sur un substratum imperméable constitué par des argiles et des marnes de l'Éocène inférieur (Agence Nationale de la Recherche Scientifique Appliquée, 2012). Les eaux de surface contenues dans les dépressions dont l'altitude est parfois négative (Fig.2), proviennent principalement d'un écoulement souterrain des eaux infiltrées (Peeters, 1998).

Ces contextes géologique et géomorphologique traduisent une vulnérabilité naturelle des Communes de l'étude face aux fluctuations eustatiques et aux inondations pluviales dont les effets sont fortement accentués par la forte réactivité de la nappe phréatique pendant la saison des pluies. Cette vulnérabilité s'est considérablement accrue avec l'extension des aires urbanisées aux cours des décennies de sécheresse (1971-1980, 1981-1990 et 1991-2000) (*Cf.* Fig.4).

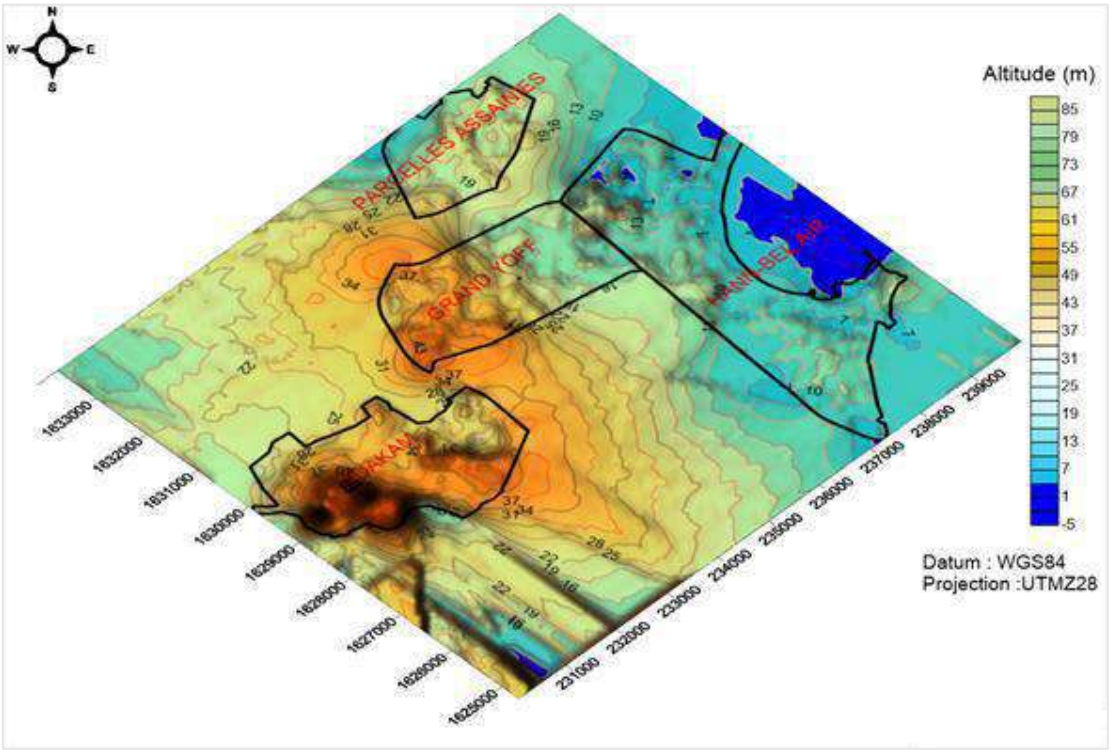

Fig.2. Morphologie des Communes de Hann-Bel-Air, Grand-Yoff, Parcelles et Ouakam (Source : THIAW et al., 2021)

Au plan pédologique, l'altération physico-chimique des massifs sableux des Niayes de la région de Dakar a donné naissance à deux grandes familles de sols (Fig.3) :

- Les sols ferrugineux tropicaux faiblement lessivés dits sols « Dior » sont situés sur les dunes de la côte. Ces sols sont formés en présence d'oxyde de manganèse, de fer ou d'alumine. Ces types de sols sont bien drainés dans leur horizon de surface et pauvres en matière organique. Ils constituent les formations pédologiques dominantes des Communes de Hann-Bel-Air, Parcelles Assainies, Grand-Yoff et Ouakam.
- Les sols hydromorphes sont localisés essentiellement dans des dépressions inter-dunaires (cuvettes, zone humide…) ; On les retrouve au nord de Hann-Bel-Air (quartiers de Hann-Mariste-Air et Hann-Sur-Mer). Ce sont des sols caractéristiques des Niayes proprement dites inondés de manière permanente ou temporaire par les débordements de lacs ou des cours d'eau. Ils sont sableux et enrichis en matière organique et constituent la zone de prédilection des activités maraîchères et de la floriculture.

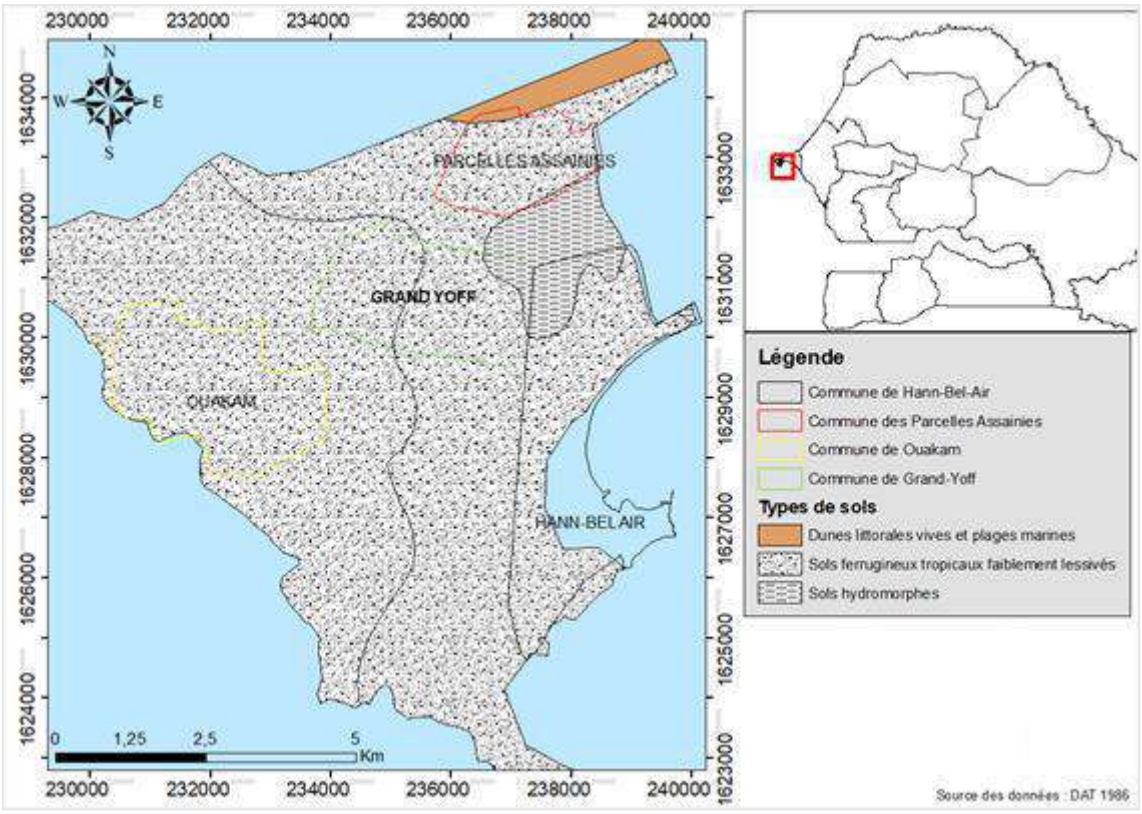

Fig.3. Carte des types de sols des communes cibles

1.1.2. Contexte Climatique

Le climat des Communes de l'étude appartient au domaine sahélien côtier (isohyète 100-500 mm) dont les mécanismes et les processus sont commandés essentiellement par les anticyclones des Açores et de Sainte-Hélène qui structurent et organisent les deux grandes saisons qui y sont notées : la saison des pluies et la saison sèche. Deux grands flux intéressent alternativement les Communes de Ouakam, Parcelles Assainies, Grand-Yoff et de Hann-Bel-Air :

- L'Alizé maritime, frais et humide, alimenté par l'anticyclone des Açores, régit en grande partie le temps pendant la saison sèche. Il s'agit d'un flux quasi-permanent chargé d'embruns saturés en eau salée et mobilise souvent des sables dunaires qui envahissent les dépressions, les zones d'habitation et les axes routiers.
- Le flux de mousson, émis par l'anticyclone de Sainte-Hélène, en saison des pluies, favorise les lignes de grains et la remontée de l'Equateur Météorologique dans l'ensemble des Communes de l'étude. Les pluies surviennent généralement entre juin et octobre avec un maximum en août (Fig.3). Elles sont peu abondantes et dépassent rarement 500 mm par an (Fig.4) dans la région de Dakar.

Le climat de la région se caractérise par une forte variabilité interannuelle et saisonnière de la pluviométrie, marquée notamment par une grande sécheresse au cours de la période 1970-1993 et une reprise de la pluviosité au début des années 2000 (Fig.4). Ce caractère irrégulier des pluies accentue la vulnérabilité de l'Agriculture Urbaine et Périurbaine (AUP) des Niayes, qui est très dépendante des pluies, et compromet ainsi, sévèrement, la sécurité alimentaire et les capacités de résilience ou d'adaptation des populations.

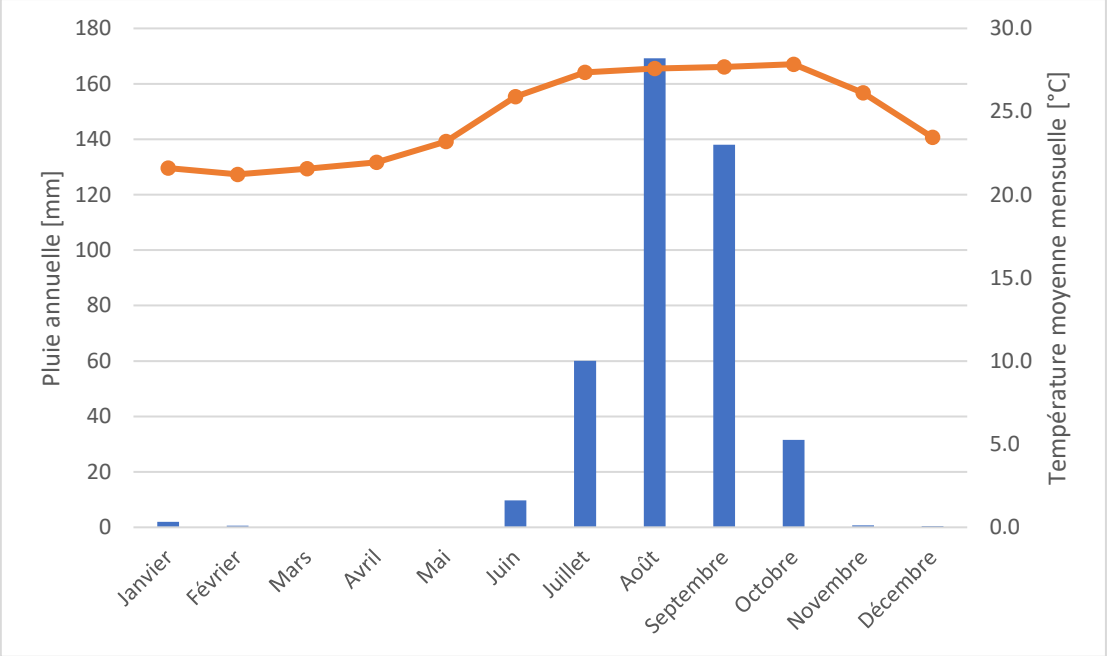

Fig.3. Diagramme climatique de la région de Dakar (source : THIAW et al. 2021)

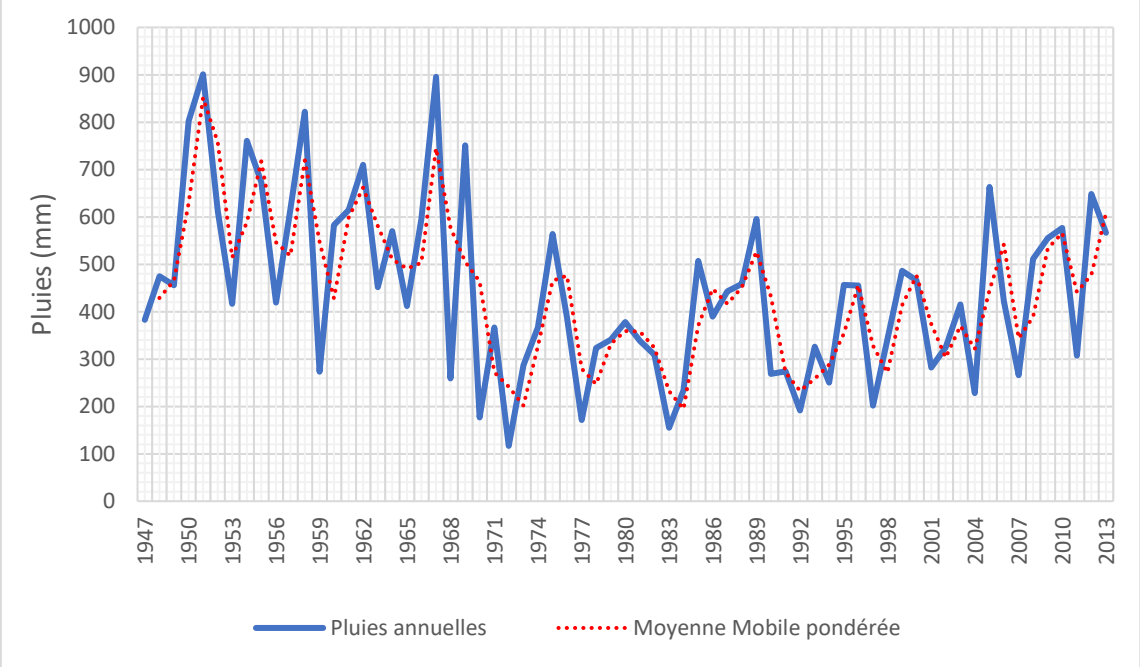

Fig.4. Variation des pluies moyennes annuelles de la station de Dakar de 1947 à 2013 (Source : THIAW et al. 2021)

1.1.3. Contexte Socio-économique

La population des Communes de l'étude est comprise entre 67 961 (Hann-Bel-Air) et 185 503 habitants (Grand-Yoff) ; soit une densité qui varie de 6 472 à 29 445 habitants/km² (Tab.1), d'après les résultats du dernier recensement de la population sénégalaise (ANSD, 2013). Elle est constituée, en moyenne, de 50,3% d'hommes et de 49,7% de femmes, mais avec une très large prédominance des jeunes de moins de 25 ans, qui représentent plus de 60 % de la population.

Cette forte démographie traduit une course effrénée pour l'accès au foncier, à l'emploi, et aux services sociaux de base (santé, éducation, électricité, télécommunication, eau et assainissement…). En plus, la variabilité notée sur les ressources en eau et ses effets induits (inondation, manque d'eau, baisse de la fertilité des sols…), affecte

considérablement les performances agricoles. C'est pourquoi, l'économie locale des Communes de l'étude est surtout dominée par des activités économiques de proximité telles que le maraîchage, la floriculture, l'artisanat, la pêche et le secteur informel (vendeurs ambulants, laveurs de voiture, cireurs, travailleurs domestiques, lingères, restauratrices de rue, etc.).

Tableau 1. Caractéristiques démographiques des Communes de l'étude (source ANSD, 2013)

COMMUNES	CONCESSION	MENAGES	HOMMES	FEMMES	POPULATION	Densité (Habitant/Km²)
Grand-Yoff	12 314	38 266	93 053	92 450	185 503	29 445
Hann-Bel-Air	5 872	12 638	33 997	33 965	67 961	6 472
Parcelles Assainies	10 942	27 921	80 792	78 706	159 498	45 571
Ouakam	6 955	14 225	37 103	37 362	74 465	10 903

III. MATERIELS ET METHODES

1. Collecte des données : unité de sondage et taille de l'échantillon

La collecte des données a été menée auprès des producteurs et productrices des Communes de Ouakam, Parcelles Assainies, Grand-Yoff et Hann-Bel-Air dans lesquelles le manque d'espace de culture a favorisé l'émergence d'une nouvelle forme d'agriculture dite "cultures sur table". Une agriculture écologique de type familiale et où les superficies exploitées sont très petites, mais qui contribue tout de même à satisfaire les besoins alimentaires et non-alimentaires des ménages agri-urbains. L'échantillon est basé sur un groupe cible de 120 individus définis suivant la méthode d'échantillonnage usuelle de BERNOULLI. Les données ont été recueillies au moyen de questionnaires et d'entretiens semi-directifs avec 10 focus groupes en mars et octobre 2021.

1. Traitement et Analyse des données socio-économiques

Le traitement et l'analyse des données issues de l'enquête de terrain ont été abordés selon une approche pluridisciplinaire avec l'utilisation des méthodes de la géographie et de la sociologie (analyse qualitative et quantitative). Les résultats ont fait l'objet d'une analyse univariée, bivariée et multidimensionnelle à l'aide des logiciels SPHINX et XLSTAT.

La première opération a consisté, après saisi des données d'enquête sur SPHINX (analyse quantitative et qualitative), à un contrôle de qualité qui a permis de faire des corrections et des redressements. Dans un second temps, toutes les données ont été transférées dans un outil de synthèse, de traitement et d'analyse statistique (logiciel XLSTAT). En termes d'approche d'analyse des données quantitatives, plusieurs méthodes ont été utilisées, notamment des analyses descriptives (univariées et bivariées) pour analyser la relation entre les différentes variables. Pour l'analyse des données qualitatives, les réponses recueillies, au cours de l'enquête sont traitées par la technique de l'analyse thématique. L'analyse de contenu et l'analyse thématique sont menées, d'une part, pour faire ressortir la diversité des facteurs explicatifs et, d'autre part, pour répondre aux objectifs de l'étude.

IV. RESULTATS ET DISCUSSIONS

1. Niveau d'instruction et répartition ethnique des maraîchers

Sur un échantillon de 120 producteurs/productrices, près de 72% sont instruits : 15% au cycle de l'enseignement primaire, 45% au moyen secondaire et 12 % ont au moins fréquenté un Dara ou école coranique (10%) ou ont été alphabétisé (2%) (Fig.13). Ce constat est similaire à celui fait dans les travaux de Niang (2014).

Les enquêtes de terrains ont révélé que la majorité des acteurs intervenant dans le maraîchage est instruit, seulement 28% déclarent n'avoir jamais fréquenté une école française ou un Dara (école coranique). Ils sont constitués essentiellement de Wolof (38%), de Serer (22%) et de Toucouleur (10%).

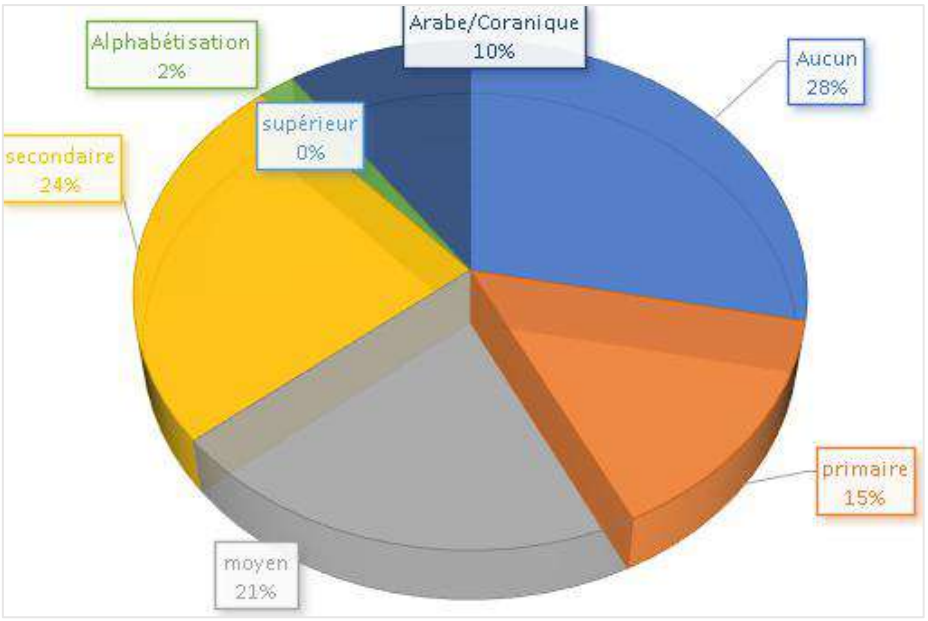

Fig.13. Niveau d'instruction des maraichers et maraichères

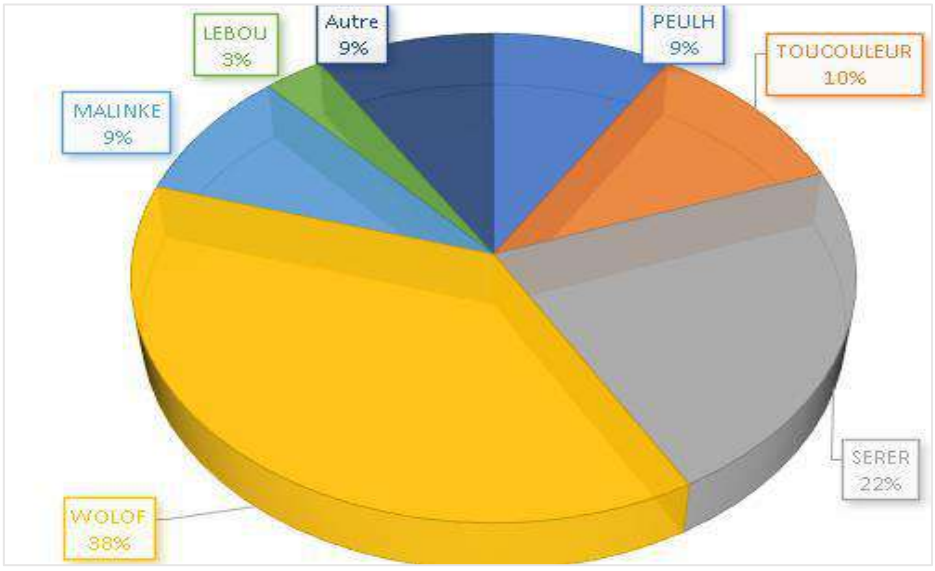

Fig.14. Répartition ethnique des maraichers et maraichères

2. Vers une féminisation du secteur agricole ?

Longtemps considéré comme une activité presque exclusivement masculine (Dugué *et al.* 2017 ; Ba et Cantoreggi, 2018), le maraîchage, dans cette partie des Niayes de la région de Dakar est, aujourd'hui, dominé par les femmes (Fig.15). Cette situation est liée au manque de terres de culture, conséquences de la forte urbanisation qui bloque toute possibilité de cultures extensives, obligeant ainsi les hommes à changer d'activité. Ainsi, il se développe dans ces zones un nouveau type d'agriculture essentiellement féminine, dite "agriculture sur table". Les acteurs et actrices de cette activité ont entre 27 et 74 ans, mais avec 96% qui ont plus de 40 ans.

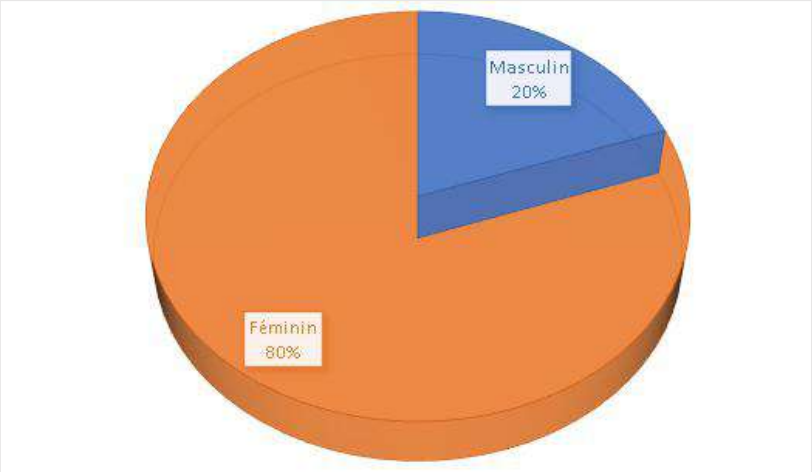

Fig.15. Répartition par genre des acteurs et actrices du maraichage

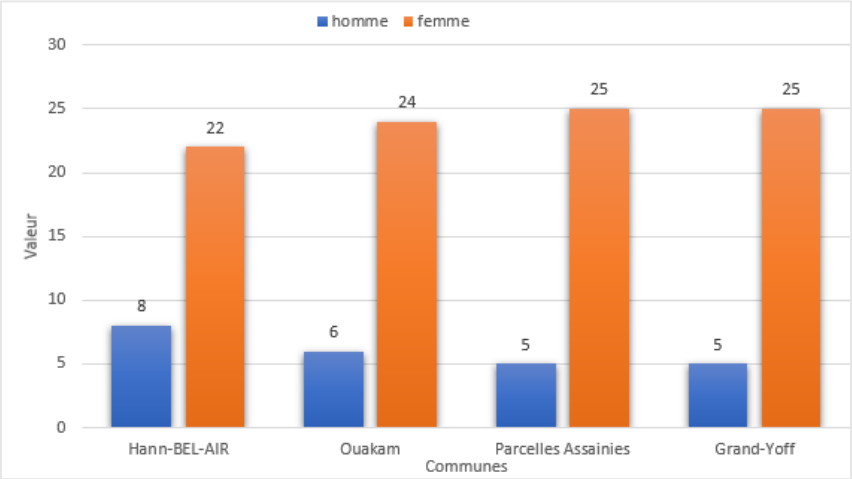

Fig.16. Répartition par genre par Commune des acteurs et actrices du maraichage

Photo 1. Culture sur table à Ouakam, Grand-Yoff et Parcelles Assainies

Le maraîchage dans les Communes de l'étude est une activité menée principalement par des femmes assez expérimentées. Les enquêtes de terrain ont montré que 23% des maraichers/maraichères interrogés ont plus de 12 années révolues dans la pratique agricole en milieu urbain ; plus de la moitié (53%) ont entre 10 et 12 années, alors que près de 20% y sont depuis moins de dix ans (Fig.17). Cette situation dénote aussi un certain renouvellement des acteurs dans cette filière consécutive à l'abandon de l'agriculture extensive, né de l'urbanisation ininterrompue de l'agglomération dakaroise et de sa marginalisation par les pouvoirs publics.

Fig.17. Nombre d'années passées dans l'activité agricole

Cette activité est dominée par des veuves (44%) et des mariées polygames (41%) (Fig.18) demandeuses de revenus supplémentaires pour satisfaire les besoins alimentaire, sanitaire et scolaire de leurs ménages. Ces derniers sont compris généralement entre 5 et 10 personnes (Fig.19).

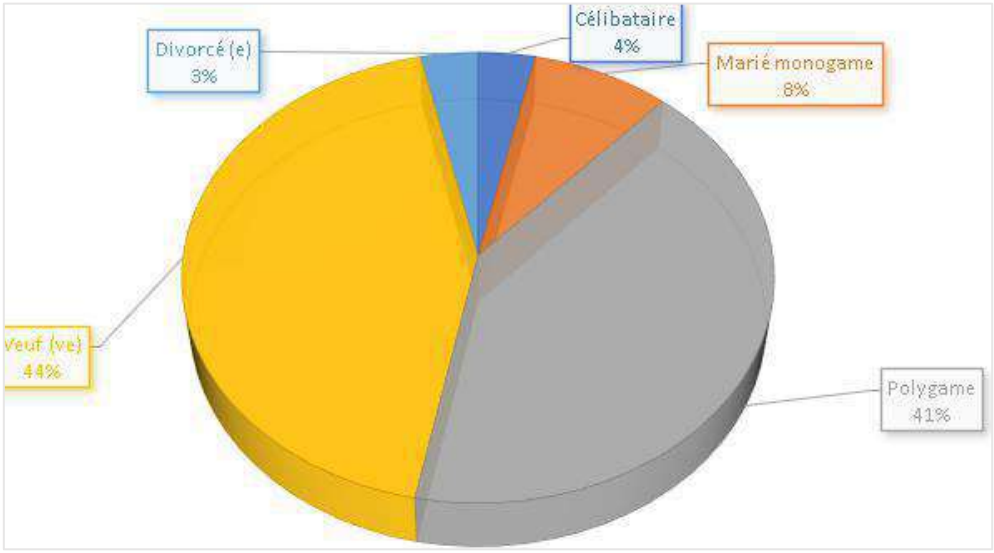

Fig.18. Situation matrimoniale des maraichers et maraichères

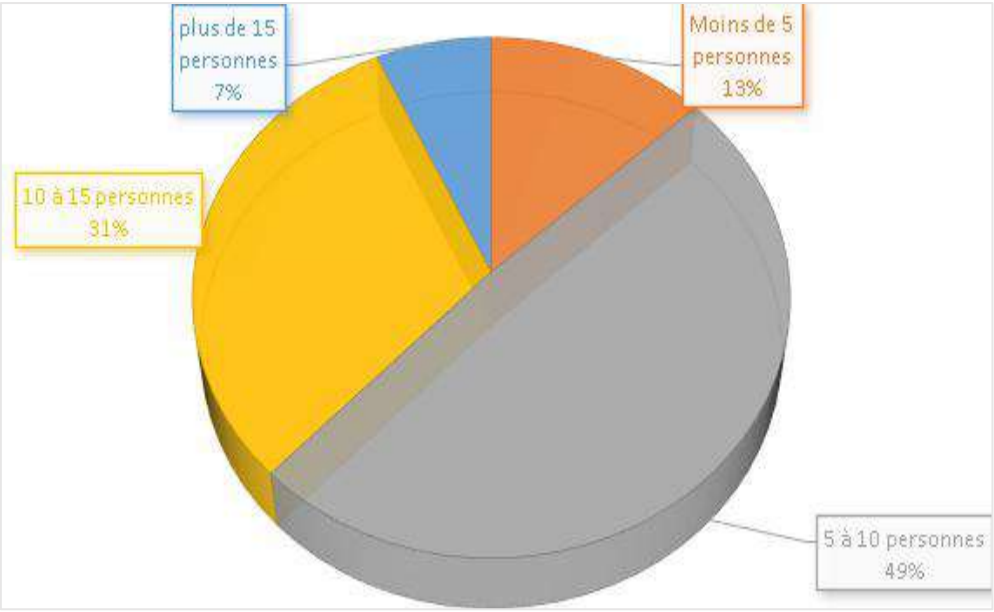

Fig.19. Répartition de la taille des ménages

Les enquêtes de terrain ont aussi révélé que 76 % des maraichers et maraichères sont propriétaires de leur logement et 21% sont des locataires (Fig.20).

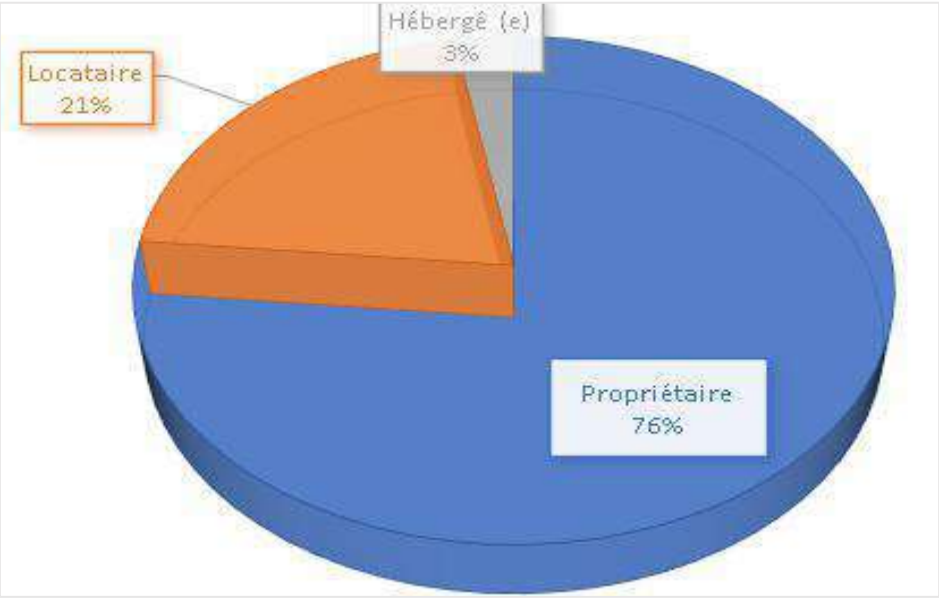

Fig.20. Statut d'occupation du logement

3. Une situation foncière précaire et ambiguë

La situation foncière permet d'interroger les modalités d'accès à la terre des producteurs et productrices des Communes de l'étude. Les résultats montrent que les maraichers et maraichères des communes de l'étude ne sont pas propriétaires des parcelles qu'ils/elles exploitent. En effet, la plupart des agriculteurs accèdent à la terre par prêt (70%) ; 5 % y accèdent par don ou par location, tandis que 17% des agriculteurs se considèrent être dans une situation d'occupation anarchique (Fig.21).

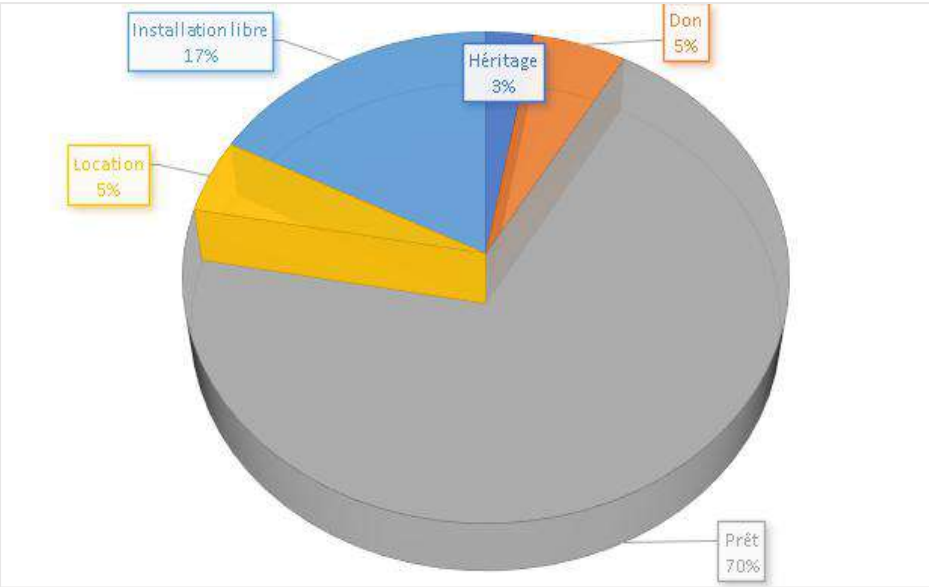

Fig.21. Répartition des maraichers/maraichères selon le statut foncier

Par ailleurs, le caractère informel de cette forme de tenure foncière (installation libre) accentue la précarité de la situation des agriculteurs puisqu'elle ne leur permet pas d'obtenir des crédits au niveau des institutions financières en mettant sous hypothèque ou sous garantie leur exploitation agricole. De plus l'ambiguïté des superficies agricoles exploitées constitue également un frein pour les bailleurs qui préfèrent investir dans de grandes exploitations agricoles.

Dans les Communes de Parcelles Assainies, Grand-Yoff, et Ouakam, les activités maraichères se font en effet sur de petites surfaces avec plus de 75% inférieurs à 500 m² : 40 % des acteurs/trices exploitent moins de 200 m² et 38% entre 200 et 500 m² (Tab.2 & Fig.22). Le nombre de tables exploitées donne une moyenne de 15 tables/femme et un écart type de 10,1 qui témoigne de l'hétérogénéité des surfaces exploitées. Cependant, à Hann-Bel-Air, les superficies exploitées sont beaucoup plus importantes comparées aux autres Communes de l'étude, car les activités agricoles sont menées dans son parc agroforestier ; les superficies se situent majoritairement entre 200 et 1000m², avec 39% entre 200 et 500m² et 44% entre 500 et 1000m² (Tab.2 & Fig.22). Cette ambiguïté des exploitations agricoles dans les communes de l'étude confirme les résultats des travaux faites dans la zone des Niayes par plusieurs auteurs dont Niang, (2014) ; Dugué *et al.* (2017) ; Ba et Cantoreggi (2018).

Tableau 2 : Superficie exploitée par les acteurs et actrices du maraichage par Commune

Superficie exploitée	Moins de 200 m²	200-500m²	500-1000 m²	+ de 1000 m²
Hann-BEL-AIR	1	11	13	5
Ouakam	15	12	2	1
Parcelles Assainies	17	11	2	0
Grand-Yoff	15	9	5	1

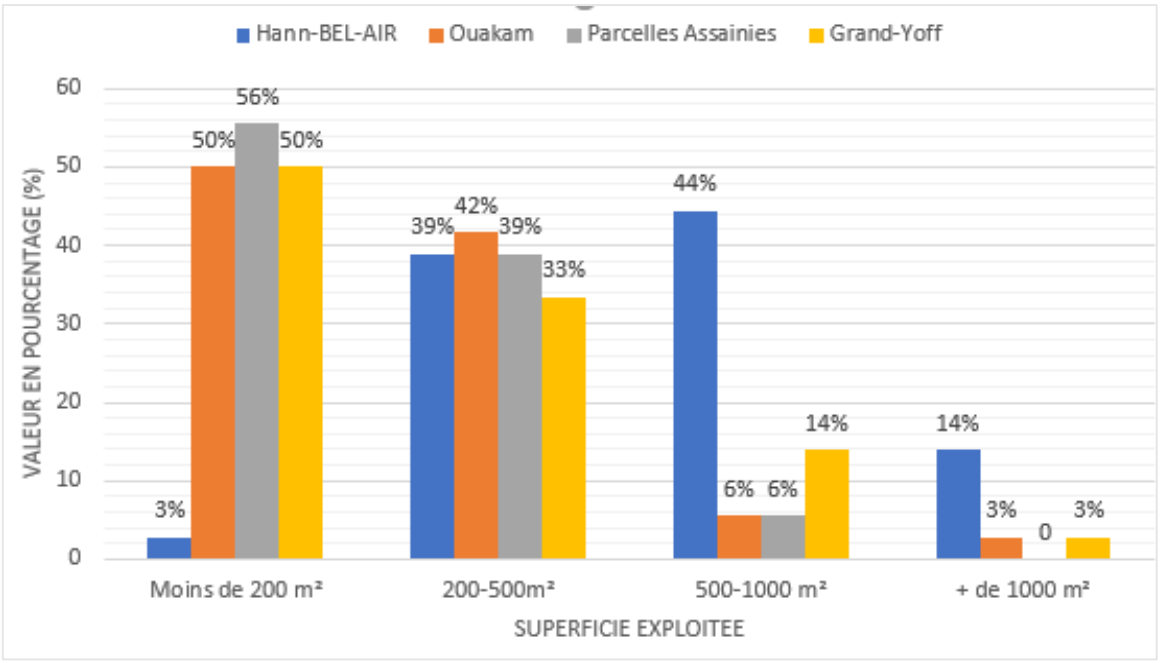

Fig.22. Répartition des acteurs et actrices du maraichage selon la superficie cultivée par Commune

Photo 2. Maraichage dans le parc forestier de Hann-Bel-Air

4. Aperçu des principales spéculations cultivées

Du fait de son caractère d'activité urbaine, le maraichage des Communes de l'étude est dominé par des cultures à cycle relativement court. Ces cultures peuvent être classées en deux catégories : les légumes à feuilles et les légumes à fruits. Les légumes à feuilles sont les plus cultivées et sont constituées principalement de la menthe persil ou Nana (85,5% des spéculations cultivées), de la salade (95,2%), et du choux (87,6%) ; tandis que les légumes à fruits dominantes sont l'oignon (66,2%) et le piment (71%) (Fig.23).

Il s'agit de cultures destinées généralement à satisfaire les besoins de subsistance des producteurs et productrices des Communes cibles. Cela est davantage confortée par plusieurs recherches qui voient en l'AUP des Niayes une activité de subsistance pour les ménages les plus démunis (Dugué *et al.* 2017 ; Ba et Cantoreggi, 2018).

Photo 3. Cultures légumières dans les Communes de l'étude

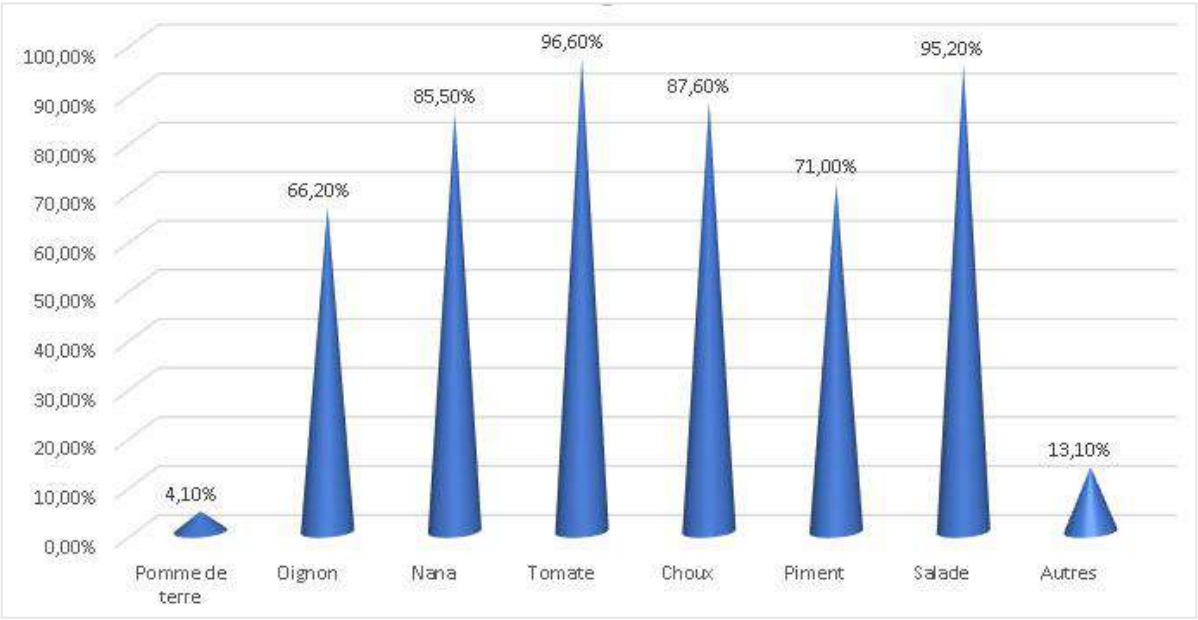

Fig.23. Les types d'espèces cultivés dans les Communes de l'étude

5. *Les sources et modes d'irrigation*

La majorité des maraichers s'approvisionne directement dans la nappe phréatique – peu profonde du fait de l'appartenance des Communes de l'étude à zone agroécologique des Niayes – soit à l'aide de motopompe ou manuelle via des puits et ou céanes, ou soit par l'adduction à la SEN-EAU (Fig.24). La disponibilité de cette eau nécessite un certain effort physique (arrosoirs, pioches, seau, poulie …) ou financier (achat de motopompe, gasoil, payement de facture d'eau…). De surcroit, les épisodes de sécheresse de la période 1970-1993 et la forte irrégularité des pluies notée à partir des années 2000, ont induit une variabilité similaire aussi bien sur les ressources en eau de surface, mais aussi sur les ressources en eau souterraine. De ce fait, plus de 90% des agriculteurs des Communes de l'étude font face à des problèmes d'eau pour l'arrosage des pépinières.

La dernière source d'approvisionnement en eau à Dakar est relativement nouvelle et très peu répandue à l'échelle de la région. Il s'agit de l'utilisation des Eaux Usées Traitées (EUT) fournies depuis 2012 par les Stations d'Epuration (STEP) grâce à un programme initié par la FAO et qui a permis l'installation d'un réseau d'adduction allant des STEP aux zones de production concernées.

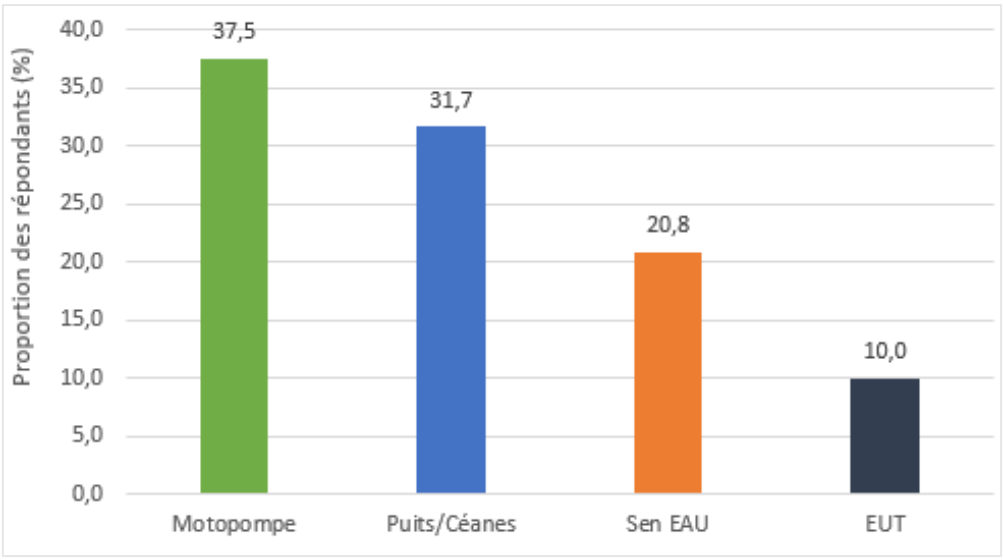

Fig.24. Les Principales sources d'irrigation

6. *Techniques de conservation ou de protection des sols*

L'utilisation des déchets organiques (compost, fumure minérale) comme fertilisants occupe une place prépondérante dans les activités maraichères des Communes de l'étude. En effet, les enquêtes de terrain ont révélé que 60% des maraîchers et maraîchères utilisent exclusivement de l'engrais biologique (coques d'arachide, crottins d'ovin ou/et de cheval, ou fiente de volailles…) pour l'entretien des plantes, 40% de l'engrais mixte (engrais bio et chimique). Cependant, trente-trois maraichers sur trente-six de la Commune de Hann-Bel-Air utilisent, en plus des déchets organiques, de l'engrais chimique dont les plus récurrents sont les pesticides (48%), les herbicides (45%), l'urée (4%) et le NPK (3%) (Fig.25&26). Cette situation augmente le risque de contamination et de pollution des hydroécosystèmes de la Commune de Hann-Bel-Air. Ce constat est similaire à celui fait dans les travaux de IAGU (2011) et Niang (2014).

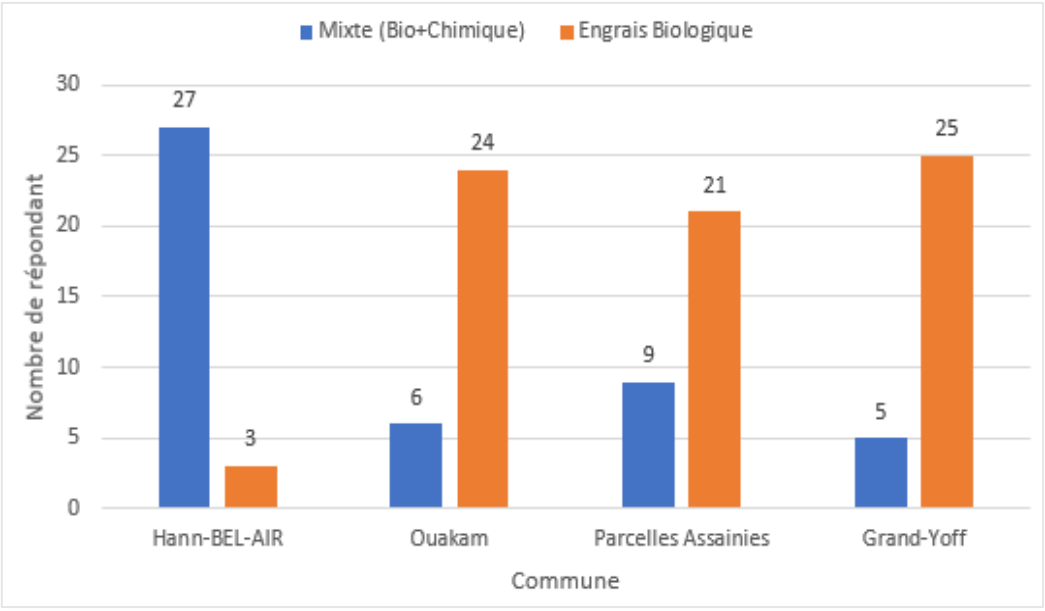

Fig.25. Usage de fertilisants agricoles

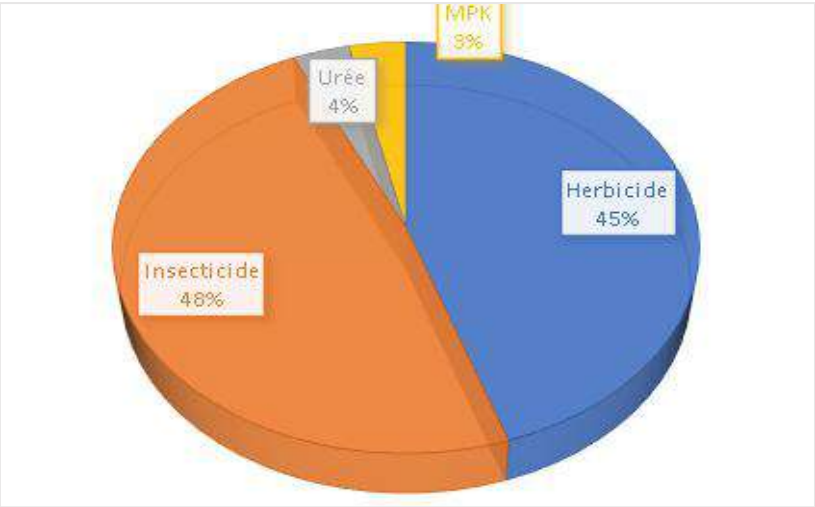

Fig.26. Types d'engrais ou intrants chimiques utilisés dans la mise à valeur

7. Le Système d'appui de proximité

Les maraîchers/maraichères des Communes de Hann-Bel-Air, Grand-Yoff, Parcelles Assainies et Ouakam, à l'image de toute l'économie urbaine des Niayes, souffre d'un système d'appui de proximité performant. En effet, à peine huit maraîchers/ sur 120 bénéficient des supports des municipalités ; 1/120 des services étatiques et 12/120 des Partenaires Techniques et Financiers (PTF) (Fig.27) en termes de matériels agricoles, de financements ou de formations techniques. Ces acteurs externes sont surtout présents dans les Communes de Hann-Bel-Air et de Ouakam.

Les maraichers et maraichères sont autonomes dans leurs activités, et, en dépit de la quasi absence d'appuis, manifestent une résilience à toute épreuve. Les rares appuis des Partenaires Techniques et Financiers (PTF) se sont montrés louables dans les principes, néanmoins n'ont pas connu de continuité. Les plus présents sur le terrain sont la FAO et Enda Graf Sahel qui, d'après la population enquêtée, ont contribué à renforcer leur capacité d'adaptation.

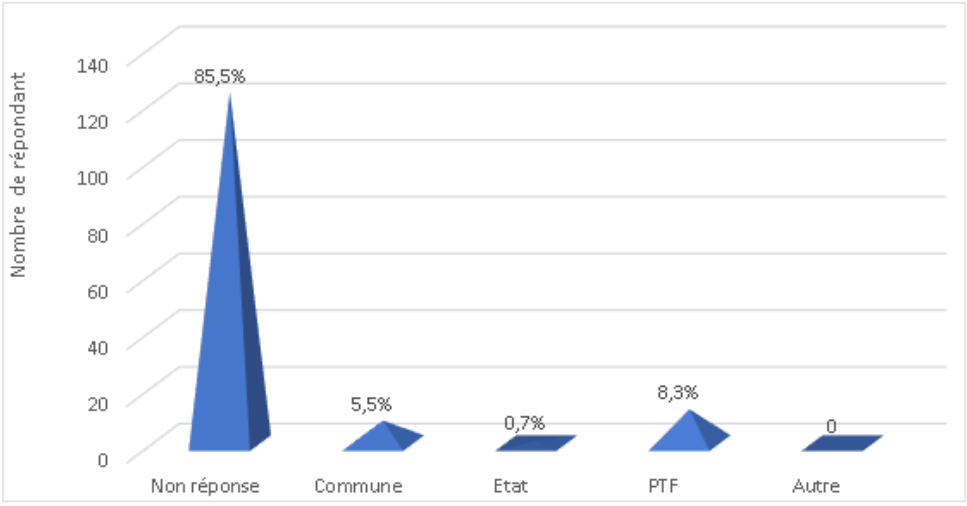

Fig.27. Les auteurs des appuis financiers et/ou techniques

9. Revenus agricoles des maraîchers et maraîchères des Communes cibles

L'esquisse du compte d'exploitation des maraîchers/maraîchères montre que le revenu net moyen par campagne et par maraîcher/maraîchère obtenu à partir de la moyenne des quatre Communes (Hann-Bel-Air, Grand-Yoff, Parcelles Assainies et Ouakam) est de 531 609 Fcfa (soit 811,62 euros/campagne/maraicher). Sachant que près de 98% des exploitants interrogés mènent quatre campagnes par année, on obtient un revenu net annuel moyen pour un maraîcher/maraîchère de 3 246,5 euros/an, soit un revenu mensuel de 270,54 euros (177 203

Fcfa) ; en comparaison, le Salaire Minimum Interprofessionnel Garanti (SMIG) et le salaire moyen d'un employé sénégalais sont respectivement de 55 et 174 euros (ANSD, 2016).

Ce revenu constitue aussi l'essentiel des ressources des maraîchers et maraîchères des Communes de l'étude (Tab.3). Il améliore les conditions de vie des maraîchers et maraîchères à travers le renforcement de leurs capacités à investir dans les postes de dépenses centraux (alimentation, santé, scolarité et logement). Cela est davantage confirmé dans plusieurs études qui voient en l'agriculture périurbaine de Dakar comme une activité exclusivement commerciale permettant aux ménages agri-urbains de mieux couvrir leurs dépenses alimentaires et non-alimentaires inhérentes à la vie en milieu urbain (Gaye et Niang 2010 ; Dugué *et al.*, 2017 ; Ba et Cantoreggi, 2018).

Tableau 3. Structure des principaux postes de dépenses des maraichers/maraichères

Commune	Types de dépenses	Acteurs/Actrices du maraichage	
		Charge mensuel (Fcfa)	Contribution mensuelle (en Fcfa)
Parcelles Assainies	Alimentation	204 028,57	115 156,82
	Santé	23 153,85	17 846,15
	Scolarité	24 875	19 562,5
	Location (logement)	67 000	52 500
	Total	**319 057,42**	**205 065,47**
Ouakam	Alimentation	213 028,57	122 121,21
	Santé	16 900	13 277,78
	Scolarité	35 894,74	19 842,11
	Location (logement)	71 857,14	59 000
	Total	**337 680,5**	**214 241,1**
Grand-Yoff	Alimentation	196 264,7	100 484,85
	Santé	18 090,9	11 818,18
	Scolarité	27 263,1	20 850
	Location (logement)	71 000	46 428
	Total	**241 618,70**	**112 303,03**
Hann-Bel-Air	Alimentation	212 457,14	120 294,12
	Santé	16 900	13 277,78
	Scolarité	35 894,74	19 842,11
	Location (logement)	72 571,43	54 166,67
	Total	**337 823**	**207 581**

8. Les Principales contraintes rencontrées par les maraîchers/maraîchères

Le maraichage des Communes de l'étude, à l'image de toutes les activités agricoles pratiquées dans les Niayes, doit faire face à d'importantes contraintes dont la plupart sont inhérentes à son caractère d'activité urbaine. Les principales contraintes identifiées par les maraichers et maraichères sont, par ordre d'importance, la crise sanitaire de la COVID-19 (93,8%), le problème de financement (68,3%), le manque de matériels agricoles (67,6%), la pression foncière (64,8%), la prolifération des ravageurs (54,5%) et le manque d'eau pour l'irrigation (48,3%) (Fig.28). Toutefois, il faut noter que le manque d'eau est moins mentionné à Hann-Bel-Air en raison de la présence, pendant toute l'année, des ressources en eau de surface (le lac du parc forestier). Ces résultats corroborent les travaux antérieurs de Gaye et Niang (2010), IAGU (2011) et Niang (2014).

D'autres contraintes moins préoccupantes que ces principales entravent également le bon fonctionnement des activités maraichères. Il s'agit, entre autres, des contraintes climatiques principalement les inondations (18,6%) et le

problème lié au système d'appui de proximité en termes d'encadrement technique des producteurs (37,9%) (Fig.29). Ces résultats corroborent les travaux de Ba et Cantoreggi (2018).

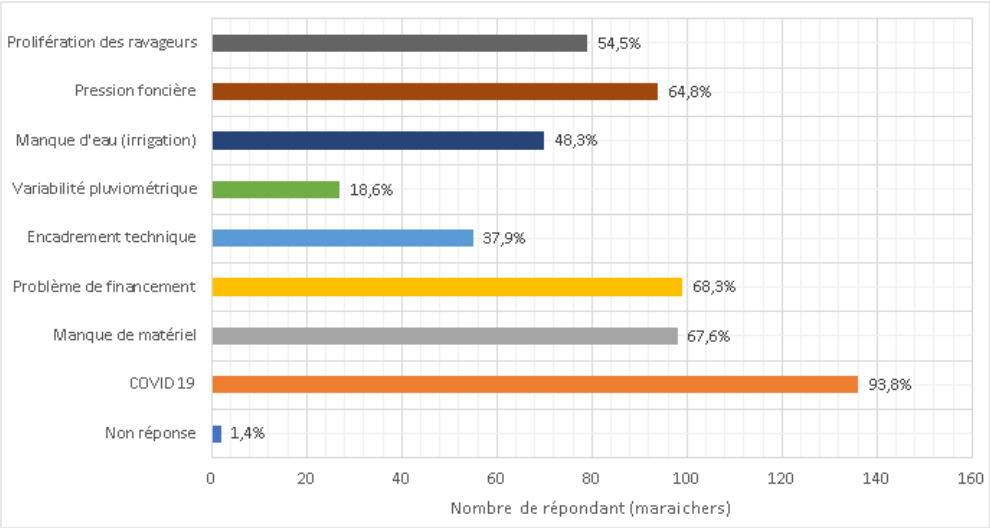

Fig.28. Nature et niveau d'importance des contraintes pour les maraichers et maraichères

Pour surmonter ces obstacles, les maraichers ont identifiés trois principaux besoins de formations. Il s'agit de la mise en place de pépinières biologiques (74,5% des maraichers), de technique de production d'engrais naturels (63,4%) et une formation sur la planification culturale et les techniques d'entretien des cultures (51,7%) (Fig.28). Si à Ouakam et Parcelles Assainies ces besoins ont leur même niveau d'importance, à Hann-Bel-Air, par contre, la planification culturale et les techniques d'entretien des cultures priment sur les autres. À Grand-Yoff, c'est la mise en place de pépinières bios qui est le principal besoin en formation.

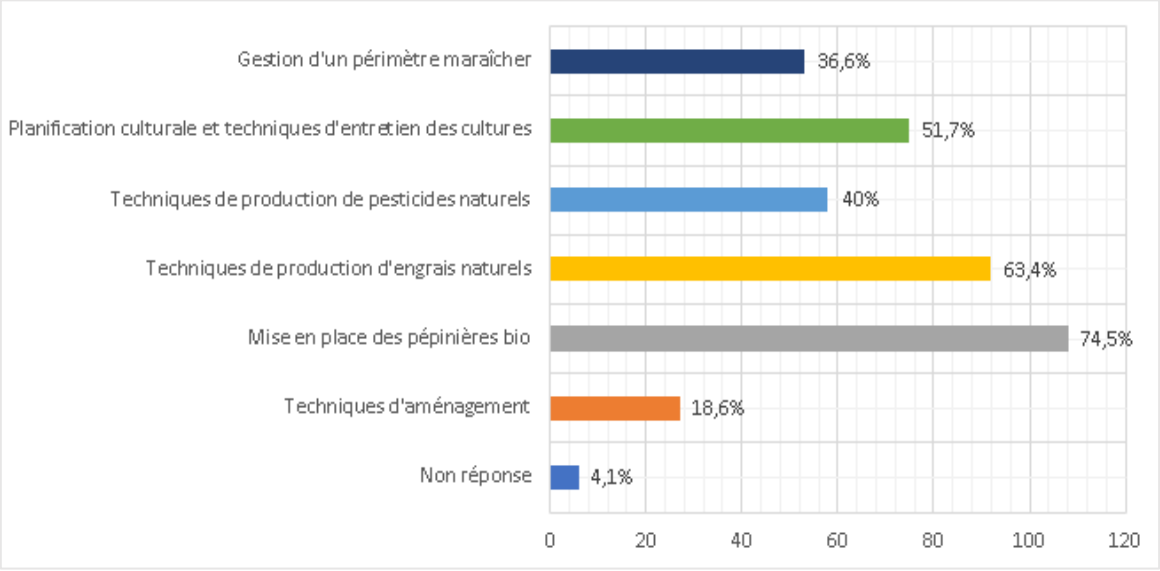

Fig.29. Besoins prioritaires de formation identifiés par les maraîchers et maraîchères

V. CONCLUSION

Le maraichage dans les communes de l'étude est marqué par l'émergence des cultures sur tables, en réponse à la forte pression démographique qui a entrainé l'occupation des sols jusque dans les zones non aedificandi. Porté majoritairement par les femmes, il constitue une activité commerciale à part entière dont les revenus monétaires sont de loin plus importants que le salaire minimum au Sénégal. Il s'avère que cette orientation presque exclusivement commerciale permet indiscutablement aux femmes de mieux couvrir leurs dépenses alimentaires et non-alimentaires inhérentes à la vie en milieu urbain.

Par ailleurs, plusieurs travaux ont mis en exergue l'apport des activités agricoles urbaines dans l'approvisionnement alimentaire des ménages agri-urbains sous le prisme d'une activité d'autoconsommation (Casale, 2006, Mfoukou-Ntsakala *et al*., 2006, Olahan, 2010). Si cette réalité n'est pas à sous-estimer, force est de constater que l'AUP revêt de plus en plus un caractère marchand dans les pays en voie de développement (Niang, 2014 ; Duqué et al. 2017 ; Ba et Cantoreggi 2018) et récemment dans certains pays développés (Aubry, 2013 ; Toullalan, 2012), ce qui lui permet de mieux jouer son rôle en matière de sécurité alimentaire des ménages agri-urbains. Cependant, ce secteur doit faire face à d'importantes contraintes dont la plupart sont inhérentes à son caractère d'activité urbaine. Les principales contraintes identifiées par les maraîchers et les maraîchères sont entre autres le problème de financement, le manque de matériels agricoles, la pression foncière, la prolifération des ravageurs, le manque d'eau pour l'irrigation et la crise sanitaire de la COVID-19. Pour surmonter ces obstacles, ils ont identifié trois principaux besoins de formations. Il s'agit de (i) la mise en place de pépinières biologiques, (ii) les techniques de production d'engrais naturels et (iii) une formation sur la planification culturale et les techniques d'entretien des cultures. Si à Ouakam et aux Parcelles Assainies ces besoins ont leur même niveau d'importance, à Hann-Bel-Air, par contre, la planification culturale et les techniques d'entretien des cultures priment sur les autres. À Grand-Yoff, c'est la mise en place de pépinières bios qui est le principal besoin en formation. Dès lors, il urge, de la part des autorités compétentes et des partenaires techniques et financiers, de relever ces défis pour renforcer les moyens de résilience ou d'adaptation des ménages agri-urbains à l'insécurité alimentaire et nutritionnelle.

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Quality and Food Safety of Fishery Products Marketed in Selayar Islands Regency

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Abstract— *Food safety is an obligation that much be carried out by the food industry, especially in the fisheries sector to ensure that the products marketed are safe for consumption by consumers. Public safety and health must be protected from food that does not meet the requirements and from losses due to improper food production, distribution and trade. This study aims to identify the use of dangerous chemical materials like formalin and rhodamine B in processed fishery products, as well as to determine the origin of suppliers of products sold in the Selayar Islands Regency. The method used in this research was observation. Determination of the location and sampling used accidental sampling. Samples was taken from several traditional markets that sold fishery products in Selayar Islands Regency. The samples were analyzed the quality and safety parameters in the Laboratory of the Center Implementing the Quality of South Sulawesi Fisheries Products, the Laboratory for Animal Husbandry at Hasanuddin University, the Microbiology Laboratory Department of TPHP Pangkep, and the South Sulawesi Health Laboratory. The result shows that the parameters of quality and food safety products are in accordance with SNI and there is not used of formalin and rhodamine B in any fishery products.*

Keywords— ***formalin, rhodamine B, fishery products, Selayar Islands Regency.***

I. INTRODUCTION

Selayar Islands is one of the regencies in South Sulawesi Province which is located between 5°42' - 7°35' South Latitude and 120°15' - 122°30' East Longitude bordering Bulukumba Regency to the North, The Flores Sea to the East, the Flores Sea and the Makassar Strait to the West and East Nusa Tenggara Province to the South with an area of 1,357.03 km^2. The potential of the district's marine resources is very large, so that the majority of the residents of the Selayar Islands have the main livelihood of the fisheries sector [1].

The production of capture fisheries in the Selayar Islands in 2020 reached 18,729.2 tons and increased in 2021 by 20,883.8 tons [2]. The high production of capture fisheries allows it to be used as raw materials for processed fishery products. One of them is by the method of salting or drying fish. Processors traditionally, generally pay less attention to food safety issues of the products produced.

The high production of capture fisheries in Selayar Islands Regency allows it to be used as raw material for processed fishery products. One of them is the method of salting or drying fish. Traditional prrocessors generally pay less attention to food safety issues for the products they produce.

The use of chemicals such as formaldehyde, sorbic, benzoic, and propionic acid is widely abused by traders [3]. The misuse of dangerous chemicals has become a classic phenomenon that has not been resolved because until now the use of added ingredients in food, especially formalin, is still being used as a preservative.

Public safety and health must be protected from food that does not meet the requirements and from losses due to improper ways of producing and distributing food can

harm and endanger public health. Guaranteeing quality and safe food is the responsibility of the government, the food industry and consumers, in accordance with their respective duties [4]. However, this is not the case in the field, where there is still misuse of the use of chemicals that can endanger public health [5]. The process of food safety, also known as efforts to maintain the durability of a material so that many preservatives appear which aims to extend the shelf life of a food ingredient. In practice in society, there are still many who do not understand the difference between the use of preservatives for food and non-food ingredients. Formalin is a non-food preservative which is now widely used to preserve food [6].

The misuse of harmful chemicals has become a classic phenomenon that has not been resolved because until now the use of additives in food, especially formalin, is still being used as a preservative. This study aims to identify the use of harmful chemicals including formalin, borax, and rhodamin B in processed fishery products, as well as find out the area of origin of suppliers of products sold in the Selayar Islands Regency.

II. MATERIALS AND METHODS

2.1 Samples Collection

Sampling of fishery products is carried out in traditional markets and places of production of fishery products in the Selayar Islands Regency. Samples are determined based on the types of products that are widely sold and produced in the Selayar Islands. The fishery products that are sampled from the market are fishery products produced in the Selayar Islands Regency. There are 3 places for marketing fishery products in Selayar, namely, Bonehalang market, Bonea market, and Padang market, these three markets are the marketing center for all the needs of the community in the Selayar Islands.

Sampling of fishery products is carried out by the accidental sampling method, namely by taking samples of fishery products found at the sampling location. Sampling for quality and food safety tests is by taking fishery products in each market. The sample to be tested is then put into an HDPE plastic zip to prevent contamination and taken to a laboratory for testing.

2.2 Water Content Analysis [7]

Set the oven at 105°C until it reaches a stable condition. Put the empty dish in the oven for 2 hours. Transfer the empty cup to a desiccator for 30 minutes until it reaches room temperature and weigh the empty weight (A). Weigh the sample that has been mashed as much as 2 gram into the cup (B). Put the cup that has been filled with the sample into a vacuum oven at 105°C for 24 hours. Transfer the cup using tongs to a desiccator for 30 minutes and then weigh (C).

$$\%\ water\ content = \frac{B-C}{B-A} \text{ x } 100\%$$

A = weight of empty cup (gr)
B = weight of the cup + initial sample (gr)
C = weight of the cup + dry sample (gr)

2.3 Salt Content Analysis [8]

5 grams of the sample was mashed and then extracted using 15 ml of hot distilled water (100°C). Let stand for 15 minutes until all the NaCl salt is dissolved and separated from the sample. This stage was carried out 88 times. Collect the extraction liquid in a container and add 3 ml of 5% potassium chromate. Titrate with 0,1 N $AgNO_3$ slowly until the color becomes brick red.

NaCl percentage using the equation:

$$\%\ NaCl = \frac{(\text{ml AgNO3 x } N \text{ AgNO3 x } 58{,}46)}{(\text{gram bahan x } 1000)} \text{ x } 100\ \%$$

2.4 Total Plate Count (TPC) Analysis [9]

Sample of as much as 25 g was weighed aseptically and added with 225 ml of Butterfield's phosphate-buffered solution, then homogenized for 2 minutes. This homogenates was a 10^{-1} dilution solution. Using a sterile pipette, 1 ml of the homogenate was taken and put into a bottle containing 9 ml of Butterfield's phosphate-buffered solution so that a sample with a dilution of 10^{-2} was obtained. At each dilution, shaking was carried out at least 25 times, then the same was done for the 10^{-3}, 10^{-4}, 10^{-5}, and so according to the sample conditions. Furthermore, 1 ml of each dilution was put into a sterile petri dish in duplicate using a strerile pipette. Into each petri dish containing the sample, 12-15 ml of Plate Count Agar (PCA) media which has been cooled to 45°C were added. After the agar solidified, the petri dish was put into an incubator in an inverted position for 48 hours at 35°C. After incubation the number of bacterial colonies in the petri dsih wash counted using a colony counter. Only the petri dishes containing the bacterial colonies ;psz/xbetween 25-250 colonies were used in the calculation of the total plate count (TPC).

The TPC was calculated with the following equation:

$$TPC = \frac{\sum C}{[(1 \text{ x } n1) - (0{,}1 \text{ x } n2)] \text{ x } (d)}$$

TPC = Total plate count, expressed in colony per g
ΣC = Number of colony in all plates counted
nl = Number of plates in the first dilution calculated
n2 = Number of plates in the second dilution calculated
d = First dilution

2.5 Formaldehyde Content Analysis [10]

Take 10 gr of sample then add 20 ml of distilled water. Homogenize with a blender. Put the homogenate into a glass breaker, then add 2 ml of Carrez I and II solution, stir with spatula. Adjust the pH between 7.5-8 with a solution of NaOH and HCl. If the pH is appropriate, add 6 ml of distilled water and then blend again until homogeneous. Put the homogenate into the centrifuge bottle. Centrifuge at 3000 rpm for 5 minutes. Strain the supernatant with filter paper into a new glass breaker. Separate the filtrate and put into 2 tubes of 5 ml each. Tube 1 is the sample and tube 2 is the control. Add 5 drops of Fo1 solution, shake gently and adjust pH to 13 with 1 N NaOH. Add 1 microspoon of Fo2 solution. Shake for one minute and let sit for five minutes. Record the results of reading and processing the data according to the formula formalin content (ppm) can be known by the formula:

The dilution factor is calculated by the formula:

$$Fp = \frac{\text{(g sample + V (aqua+carrez))}}{\text{sample weight (g)}}$$

Formalin content = Reading result x fp

2.6 Rhodamine B Content Analysis [11]

Determination of Rhodamine B levels using the Spectrophotometry method. Previously, the manufacture of a test solution was carried out, as much as ±5 gr of sample was put into Erlenmeyer 250 ml. the sample is then added 100 ml of 2% ammonia solution in 70% ethanol and let stand until all dyes are dissolved. The colored solution is filtered using Whatman filter paper into Erlenmeyer. The filtering results are transferred to a measuring cup and then evaporated on a hot plate for 4 hours at a temperature of 65°C. the sample that becomes concentrated during the evaporation process is then dissolved with 30 ml of aquades. The solution is introduced into a split funnel of 250 ml, then 6 ml of 10% sodium hydroxide solution is added and shaken. The solution is extracted with 30 ml of diethyl ether then shaken and allowed to stand until the solution forms 2 layers, namely a layer of clear ether (top) and a layer of red water (bottom). The water layer is then discharged through the split funnel faucet so that there is only a layer of ether called ether extract. Ether extract is washed with 0.5% NaOH solution of 5 ml by shaking and then allowing it to stand. From the washing, 2 more layers will be formed, namely a layer of clear ether (top) and a layer of brownish water (bottom). The lower water layer is discharged through the split funnel faucet so that there is only ether extract which is then extracted 3 times, each time with 10 ml of 0.1 N hydrochloric acid until the ether layer is colorless again. The ether layer is removed, the hydrochloric acid extract is accommodated in a measuring flask of 50 ml and 0.1 N hydrochloric acid is added until the mark. Then continue to make a raw solution of rhodamine B made with a concentration of 1000 mg / l / from this raw solution is made a raw solution between with a level of 20; 40; 80; 120 µg/ml. furthermore, a series of working raw solutions with a concentration of 0.4 each is made; 0,8; 1,6; 2.4 µg/ml. as a solvent, an HCl solution of 0.1 N. After completion of the above stages, it is continued with the stage of determining the level of rhodamin B dye by determining the level of rhodamine B, namely each solution is measured by visible light spectrophotometry at a wavelength of 538 nm. As for calculating the rhodamine level B in the sample, it was calculated using a calibration curve with the regression equation: y + bx ± a.

2.7 Data Analysis

The data obtained from the results of this study were then analyzed systematically descriptive to get an overview of the research results aand presented in the form of tables and graphs.

III. RESULT AND DISCUSSION

The water content, salt content, total plate count (TPC), formaldehyde content and rhodamine B content of the fishery products samples preserved with different icing methods were presented in the following tables.

Table 1. The results of testing the quality and food safety of salted fish products marketed in the Selayar Islands District

Samples	Water Content (%)	Salt Content (%)	Total Plate Count (coloni/gr)	Formaldehyde (ppm)
A1	35,42	0,28	$3,9x10^2$	0
A2	31,43	0,28	$3,4x10^2$	0
B1	32,38	0,29	$2,6x10^2$	0
B2	19,62	0,29	$4,4x10^2$	0
C1	17,41	0,24	$2,8x10^2$	0
C2	18,21	0,24	$2,4x10^2$	0

D1	23,37	0,36	$4,8x10^2$	0
D2	29,43	0,33	$1,1x10^2$	0
E1	26,88	0,31	$5,0x10^2$	0
E2	26,88	0,31	$5,0x10^2$	0

Table 2. The results of testing the quality and food safety of shrimp paste products marketed in the Selayar Islands District

Samples	Water Content (%)	Salt Content (%)	Total Plate Count (coloni/gr)	Rhodamine B (ppm)
A1	29,12	0,16	$3,5x10^2$	0
A2	26,07	0,16	$3,9x10^2$	0
B1	22,43	0,15	$4,1x10^2$	0
B2	27,12	0,18	$2,9x10^2$	0

3.1 Water Content Analysis

The water content in foodstuffs determines the freshness and shelf life of these foodstuffs, high water content makes it easy for bacteria, molds, and yeasts to breed, so that changes will occur in foodstuffs [12]. The water content is kept as low as possible to minimize the possibility of microbial spoilage breeding [13]. The high and low appearance value of the salted fish product is strongly influenced by the water content in the product. The drying time will affect the appearance, texture, taste and smell of the product. The most influential factor on the durability of a processed product is the water content. The lower the water content, the slower microbial growth so that the material can last longer. On the other hand, the higher the water content, the faster the microbes will multiply and cause decay and take place more quickly [14].

A research found that the average water content of dried anchovy (Stolephorus indicus) marketed in three markets in Barru Regency ranged from 10-12% [15]. a research states that changes in water content are strongly influenced by concentration and duration of salting. During the salting process there is a decrease in the water content because the balance in the material is disturbed due to the addition of salt, where the salt will draw water from the material and enter the tissue [16].

The results showed that the average water content of salted lencam (Lethrinus sp) and dried salted grouper (Plectropomus leopardus) marketed in the three traditional markets of the Selayar Islands ranged from 17-35%. The water content of dried salted fish based on the Indonesian National Standard is 40%. Based on the results of the water content test, the dried salted fish products marketed in the three traditional markets of the Selayar Islands are in the range of good quality and fit for consumption [17].

The preservation method that has been applied to dried salted fish is through the process of salting and drying. Salting and drying have the same goal of reducing the water content of fish food. The water content of foodstuffs has a close relationship with the durability of foodstuffs. Foods with low water content will last longer than those with high water content. This happens because the enzymatic and chemical processes as well as bacterial growth require a certain amount of water. The decrease in the water content in an ingredient will prevent the growth of bacteria and spoilage of the food [18].

3.1 Salt Content Analysis

Salt is a major factor in the process of salting fish. As a preservative in the salting process, the purity of salt greatly affects the quality of the salted fish produced. The purpose of salting foodstuffs such as fish is to reduce the water content, so that microbes, especially types of bacteria, cannot grow. Salting can also inhibit the enzyme reshuffle process so that the fish will be more durable and last longer when stored [19].

The use of low-quality salt causes dry salted fish to quickly grow red color-forming bacteria which produces an unpleasant appearance and odor. Dried fish may not be too dry as long as the salt content in the fish meat is high enough and high-quality salt is used if you want a product that lasts longer. The purity of the salt produced is highly dependent on the conditions of the seawater used and the method of salt production carried out.

Small fishermen in Selayar Islands catch fish by fishing and using nets. Some of the catches are sold in the market and some are preserved as dried salted fish. Preservation of fish is done by salting and drying. The

main purpose of salting is to extend shelf life. Fish that go through the salting process are durable because salt can inhibit and kill microbes that cause fish spoilage. After salting is complete, the fish are dried by utilizing sunlight and drying them on tarpaulins or on shelves placed in the open field.

This method is less effective due to the temperature and airflow velocity that cannot be regulated because it only depends on weather conditions and also the dried salted fish produced is prone to contamination from flies, dust, etc. organoleptic will decrease. The low quality of fish will reduce the selling price of the product [20].

3.2 Total Plate Count (TPC) Analysis

The process of processing dried salted fish carried out by producers starting from cleaning the fish has not been carried out hygienically, In the drying process using direct sunlight which is placed in an open field it is very prone to fly attacks and contamination of dirt and dust during drying so this can affect the durability save fish. If the drying / drying is not perfect, it can actually cause the fish to rot more easily, especially due to attacks by fungi, bacteria, maggots and fleas.

The occurrence of contamination by microbial pathogens, microbial toxins or heavy metal contamination and chemicals may occur during food storage, transportation, distribution or when served to consumers in traditional markets without using good packaging [21]. A raw or processed food material becomes unsafe for consumption if it has been contaminated by microorganisms. Microorganisms found in fishery products can come from various sources such as soil, surface water, dust, digestive tracts of humans and animals, and the environment where they are reared/cultivated, prepared, processed or stored.

To maintain the microbiological quality of dried salted fish products, they must be handled properly and properly. The thing to note is that when marketing salted fish in the market, it is best not to display it in an open state without using packaging, this can invite flies to come and land on the salted fish. Flies will lay eggs on salted fish that are infested and eventually salted fish contain maggots. In addition, microbiological contamination through the air and dirty places is also easy to occur, so that many salted fish are marketed to change in brown color and the formation of yellow or red stains. This occurrence is often found in salted fish products marketed in the traditional markets of the Selayar Islands.

3.3 Formaldehyde Content Analysis

After analyzing the formalin content of dried salted fish, both those taken from producers and traders, it showed that the formalin content in all samples was negative (no formalin). Formalin content in dried salted fish both in producers and traders in Selayar Islands shows a value of 0 ppm. This means that dried salted fish produced and traded inSelayar Islands is free from the use of formalin.

However, it is not certain that all salted fish sold in the market do not contain formalin. Several studies that have been conducted in the traditional market of the Selayar Islands, have found samples of dried salted fish that contain formaldehyde so that people must remain careful in buying salted fish sold in the market. Some traders admit that during the rainy season, producers usually use formalin so that the fish they preserve can dry quickly. The producers complain that the drying process is disturbed, the drying process in the rainy season takes about one week longer than during the dry season, which on average only takes 1-3 days for the drying process.

The use of formalin by salted fish producers is due to the manual method of production, drying of fish still depends on the weather. During the rainy season, drying can take days. As soon as it rains, producers immediately cover the fish that are being dried with plastic so they don't get wet. If the drying process is not perfect, the food will be easily overgrown with fungus. Foodstuffs are easily dented and destroyed, especially when the packaging is not neat and must be sent out of town. By adding formalin, the fish does not grow mold and is more durable. The use of formalin is also believed to speed up the drying process and make the physical appearance not easily damaged [22].

3.4 Rhodamine B Content Analysis

Rhodamine B is an additive coloring agent that is prohibited from being used in food products, but is widely used as a food coloring agent because of its striking color and relatively cheap price. one of the foods suspected of containing rhodamine B is shrimp paste. The basic ingredients used for the manufacture of shrimp paste are generally rebon or types of small shrimp which are processed through a fermentation process accompanied by a process of grinding and drying the shrimp paste. Shrimp paste is usually reddish brown in color, solid in shape with a slightly rough texture, and has a distinctive sharp aroma but tastes savory [23].

Based on the test results, rhodamine B levels produced 0 ppm in all tested samples. All samples from both producers and traders were tested negative for rhodamine B. Producers in the village of Dopa admitted that they did not know about the dye rhodamine B, they only knew about kesumba which is a natural dye derived from the seeds of the kesumba plant (Bixa orellana) which produces a reddish-orange color. Even so, the producers in Dopa village do not add kesumba in making shrimp paste, they

only use rebon shrimp and the brown color in the shrimp paste is the result of the raw material for rebon shrimp.

IV. CONCLUSION

From the results of tests carried out with several parameters, it can be concluded that dried salted fish products and shrimp paste show that they are safe for consumption by the public in accordance with the quality and safety standards that have been set by the Indonesian National Standards.

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Effect of spraying salicylic acid and biostimulant (Biomagic) on productivity and quality of pomegranate under heat stress in Siwa Oasis

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***Abstract*— *This study was implemented through the project (Sustainable development of fruit trees affected by some environmental stress in Matrouh governorate) funded by Regional Development Centers (RDC), Academy of Scientific Research and Technology (ASRT) (Call no. 2/2019/ASRT-RDC). It was carried out on 81 trees of Manfalouty pomegranate cv (Punica granatum) during the two successive seasons of 2020 and 2021 at the Khamisa research station of D.R.C. at Siwa Oasis-Matrouh Governorate-Egypt. The study aimed to investigate the influence of salicylic acid (SA) and the biostimulant biomagic to improve fruit productivity and the quality of pomegranate var. "Manfalouty." All the treatments were subjected to the same agricultural practice. The foliar treatments were used, tap water (T_1), salicylic acid 100 ppm (T_2), salicylic acid 200 ppm (T_3), biomagic at 7.5 cm/l (T_4), biomagic at 8.5 cm/l (T_5), salicylic acid 100 ppm + biomagic 7.5 cm/l (T_6), salicylic acid 100 ppm + biomagic 8.5cm/l (T_7), salicylic acid 200 ppm. The obtained results showed that all the treatments were affected by spraying fruit trees with salicylic acid in combination with biomagic, followed by the solo concentrations of each treatment in both seasons. Meanwhile, T_9 gave the best vegetative growth, fruit physical, chemical properties, and gave the lowest total acidity, fruit cracking percentage, and sunburn percentage in the 1st and 2nd seasons, respectively.*

Keywords*— *pomegranate, Biomagic, salicylic acid, heat stress, Siwa Oasis.

I. INTRODUCTION

The pomegranate, (*Punica granatum*) L., is a member of the Punicaceae plant family and is primarily found in semi-arid, mild-temperate, and subtropical regions. Today, pomegranate orchards are planted all over the world, but they are most popular in the Mediterranean Basin, where the fruits are of the highest quality **[Stover and Mercure, 2007; Holland et al., 2009].** One of the most significant pomegranate cultivars growing successfully in Egypt is known as Manfalouty. However, there are numerous issues with pomegranate production during the development of the trees and fruit production. Low fruit quality and cracking during maturity are the most typical issues **(Abd El-all and Fouad, 2019).**

The Siwa Oasis is located in the northern part of the Western Desert of Egypt, at the GPS (Global Positioning System) of 29.12_N latitude and 25.29_E longitude, with an elevation of 18 meters below sea level and 315 kilometers from the Mediterranean coast. It is characterized by very hot and dry climate conditions, especially during summer, and the main activity of Siwean people is agriculture, which depends on groundwater. Because that oasis is a desert closed area and has an irregular climate, and consequently heat stress during the summer season (temperatures can amount to 45 °C), almost all fruit productivity is negatively affected.

One of the most dangerous abiotic variables, heat stress reduces production and quality, which causes significant economic losses. The morphological,

anatomical, physiological, and biochemical alterations in the plant system are impacted by high temperatures. Due to inadequate understanding of heat stress at crucial periods for fruit crops, success in managing heat stress is restricted **Garcia et al. (2020)**. A pomegranate crop may suffer from heat stress and sunburn as a result of high temperatures and ultraviolet (UV) light, severely lowering the crop's commercial yield and eroding growers' profits.

The use of conventional chemicals, which have negative effects on people, animals, and the environment, is a common method used to improve the fruit quality in pomegranates. Unusual methods to improve pomegranate fruit quality are now urgently required to address the issues caused by people's careless usage of chemicals. Natural substances like salicylic acid (SA) are signaling molecules that are crucial for controlling plant growth and strengthening plants against biotic and abiotic stresses **(Hayat et al., 2010; War et al., 2012).** They also influence the quality of fruits by improving plant strength under biotic and abiotic stresses **(Kondo, 2006; Elwan and El-Hamahmy, 2009; Marzouk and Kassem, 2011)**. These natural compounds are produced in the plant in low quantities that might not boost the plant to overcome the biotic and abiotic stress. For this reason, the exogenous applications of these compounds enhance plant activity **(Abd El-all and Fouad, 2019).**

Salicylic acid (SA) participates in the regulation of numerous physiological processes in plants, including stomatal closure, photosynthesis, ion uptake, inhibition of ethylene biosynthesis, transpiration, and stress tolerance **(Khan et al., 2003; Simaei et al., 2012).** SA is an endogenous growth regulator of phenolic nature and acts as a potential non-enzymatic antioxidant. It promotes flowering, lengthens the life of flowers, delays senescence, and speeds up cell metabolism **(Bhupinder and Usha, 2003).** Plant development can be controlled by it **(Amanullah et al., 2010).**

SA application influences a wide variety of plant processes and induces antioxidant synthesis **(Yordanova and Popova, 2007)**. It is a key signal molecule for the expression of multiple modes of plant stress resistance such as salinity and drought **(Chini et al., 2004)**, chilling **(Kang and Saltveit, 2002)**, heavy metal tolerance **(Freeman et al., 2005),** heat **(Larkindale et al., 2005)**, and osmotic stress (**Borsani et al., 2001**). SA plays a crucial role in the regulation of physiological and biochemical processes during the plant life cycle, by affecting a natural series of changes, such as growth, flowering, fruit ripening, and others (**Rivas and Plasencia, 2011; Koo et al., 2020**). In addition, **Stuart et al. (2022)** said endogenous levels of SA, which are often associated with biotic and abiotic stress responses, negatively affect pollen LTMH (tolerance (Long-Term Mild Heat Tolerance). Reducing SA levels had distinct effects on anther and pollen physiology under LTMH, and found evidence for a role of JA signaling in the mechanism behind pollen thermo tolerance of the low-SA line. Sprayings salicylic induced a range of beneficial effects such as improvement in bioactive compounds, sugars, fruit size, and organic acids in fruit trees species such as apples **(Shaaban et al., 2011; Giannousis, 2012)**, pears **(Cao et al., 2006**), sweet cherries (**Yao and Tian, 2005; Giménez et al., 2014, 2017; Valverde et al., 2015),** oranges **(Champa et al., 2015; Oraei et al., 2019; García et al., 2020b)**, and plums **(Martínez et al., 2018)**

Bio-fertilization is the biological preparation containing primarily patented strains of micro-organisms in sufficient numbers. Bio-fertilizers are proven to sometimes eliminate the use of pesticides and rebalance the ratio of plant nutrients in soils. Bio-fertilizers are very safe for humans, animals, and the environment to reduce the great pollution that happens in the environment. (**Abd El-Hamied, 2019).** They are easy and safe to handle with field applications that improve their efficiency in increasing crop yields and decreasing the costs of some agricultural practices. It is worthwhile to state that, biofertilizers do not replace mineral fertilizers, but significantly reduce their rate of application (**Saber, 1993**). They are the most important for plant production and soil as they play an important role in increasing vegetative growth, yield, and fruit quality (**Soliman,2001**) in guava and banana plants; and **(Osman et al., 2010)** in olive plants, (**Chokha et al., 2000; El-Geuoshy, 2011 and Bakry et al., 2013)** on sweet orange. In addition, **Shaban and Mohsen (2009)** showed that all bio-fertilizers were effective in improving the vegetative growth and nutritional status of sweet orange transplants. **Khamis et al**., **(2014)** indicated that leaf photosynthetic pigment content (chlorophyll A, B, and carotenoids) was improved by bio-fertilizers.

Biomagic product is a biological promoter of microbial origin and contains many biological products that affect plant growth. This product consists of amino acids (Amino acids are basic ingredients in the process of protein synthesis. Plants require amino acids for overall plant growth and development), vitamins (Vitamins are essential for plant growth; they assist plants in growing by providing essential nutrients), and macro and microelements are involved in all metabolic and cellular functions **(Suman et al., 2017)**. This, in turn, increases the vegetative growth, and period of production, enhancing photosynthesis and encouraging the absorption of water and nutrients from the soil, **(El-Sibaie,1995)**. **Chokha et al**. **(2000)** stated that Volkamryana lemon and Mosambi sweet orange increased growth measurements using biomagic.

Therefore, The current study's goal is to investigate how salicylic acid and the biostimulant biomagic affect the productivity and quality of pomegranate var. "Manfalouty" fruit.

II. MATERIAL AND METHODS

This study was implemented through the project (Sustainable development of fruit trees affected by some environmental stress in Matrouh Governorate) funded by Regional Development Centers (RDC), Academy of Scientific Research and Technology (ASRT) (Call no. 2/2019/ASRT-RDC). It was conducted during the two successive seasons of 2020 and 2021 at khamisa research station Desert Research Center (DRC)at Siwa Oasis – Matrouh Governorate – Egypt on 81 trees of Manfalouty pomegranate cv (*Punica granatum*) grown under saline and heat stress to study the effect of some biological compounds (salicylic acid and biomagic) on improving quality and productivity. The selected trees were 15 years old, planted at 3X 5 m grown in sandy soil under a drip irrigation system. All are almost uniform in shape and received the common horticultural practices. Physical and chemical analysis of the experimental soil and water irrigation is shown in Table 1. Nine treatments of foliar applications, (T_1): tap water, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200 ppm, (T_4): biomagic at 7.5cm/l, (T_5): biomagic at 8.5cm/l, (T_6): salicylic acid 100 ppm + biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm + biomagic 8.5 cm/l, (T_8): salicylic acid 200 ppm +biomagic 7.5cm/l, and (T_9): salicylic acid 200 ppm + biomagic 8.5 cm/l, sprayed once every two months starting from January until the harvest time. The experiment was designed as a complete block randomized design each treatment represented by 3 replicates of 3 trees each. The analysis of the biomagic is shown in table 3. **El Massiry, (2009)**

Table 1: Some physical and chemical analyses of the experiment soil and irrigation water at khamisa research station Siwa oasis.

Particle size distribution%		**Sand**	**Silt**	**Clay**	**Some chemical analysis of irrigation water**
		81.2	8.57	10.23	
Texture soil		Sand loamy			
Ec ds/m1		9.05			6.78
pH		7.7			7.7
Units		**meq/l**			
Soluble captions	**Ca^{++}**	25			21.8
	Mg^{++}	12.1			9.7
	Na^{+}	52.1			35.95
	K^{+}	1.3			0.35
Soluble anions	**CO_3^{--}**	0.0			0.00
	HCO_3^{-}	2.8			9.5
	SO_4^{--}	26.2			10.8
	Cl^{-}	61.5			47.5

Table 2: The analysis of biomagic

Biomagic			
Amino acids(2.07%)	**Vitamins(0.04 %)**	**Ma.E(in mg/l)**	**M i. E(3.7 % in mg/l)**
Arginine	thiamine	1125 N	45 Mg
cysteine	Biotene	550 P2 O5	160 Fe
glycine	choline	625 k2O	124 Zn
histidine	folic acid		100 Mn
leucine	niacin		45 Cu
lysine	pantothenic		14 B
phenylalanine	pyridoxine		12 Mo
threonine	riboflavin		8 Co
tryptophan			
tyrosine			
valine			

The following parameters were measured:

1. **Shoot length and Leaves number /shoot:** at the end of each current season (first week of October).
2. **Leaf area (cm^2):** was determined by using the leaf area meter CL203.
3. **Total chlorophyll contents in leaf:** measured using Minolta chlorophyll meter SPAD-502 was estimated on the selected branches
4. **Yield per tree:** At harvest time, the number of fruits per each treated tree was counted and reported then the yield (kg) per tree was weighed and recorded.
5. **Fruit parameters (fruit physical characteristics)**: Fruits samples were taken at the harvest time to be used for determining the physical properties (i.e.,fruit weight (g), fruit height (cm) , and fruit diameter (cm)).
6. **Fruit quality (fruit chemical characteristics**): a sample of 10 mature fruits of each tree was taken at the harvest time to be used for determining the chemical properties (i.e., the total soluble solids percentage (T.S.S. %) that were measured using a hand refractometer, and the fruit juice is used to determine total acidity by titration against standard sodium hydroxide solution (0.1 N) using phenolphthalein as an indicator). Total sugars and vitamin C content were determined according to **A.O.A.C (1985)**.

7- **Statistical Analysis**

The obtained data were subjected to analysis of variance according to **Clarke and Kempson (1997).** Means were differentiated using the Range test at the 0.05 level **(Duncan, 1955).**

III. RESULTS AND DISCUSSIONS

Shoot length (cm), leaves number /shoot

Data in table (3), clear that shoot length and leaves number were significantly affected by all treatments in both seasons. However, T_9 gave the best shoot length (31.44 (cm) in first season, 30.17(cm) in second season) and leaves number (30.23 and 29.87) in both seasons. On the other side, T_1 gave the lowest shoot length and leaves number in both seasons.

Table.3: Effect of spraying salicylic acid and Biomagic on shoot length(cm) and leaves number of "Manfalouty" pomegranate trees during 2020 and 2021seasons.

Parameters / Treatments	Shoot length (cm)		Leaves number	
	Season 2020	Season 2021	Season 2020	Season 2021
T_1	17.19h	18.01h	17.13i	17.58i
T_2	20.56g	20.83g	18.39h	19.54h
T_3	22.19f	22.52f	20.11g	20.93g
T_4	24.17e	23.72e	22.71f	21.82f
T_5	24.75e	24.77d	24.55e	22.32e
T_6	24.63d	25.09d	25.59d	23.96d
T_7	26.80c	26.80c	27.39c	26.12c
T_8	28.66b	28.80b	28.45b	28.79b
T_9	31.44a	30.17a	30.23a	29.87a

Means having the same letter (s) in each column is not significantly different at 5% level. * (T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%,(T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Leaf area (cm^2) and leaf total chlorophyll (SPAD)

It could be noticed from table (4) that all treatments were significantly affected in leaf area and leaf total chlorophyll in both seasons. However, T_9 gave the best leaf area(5.96 cm^2 and 6.13 cm^2) and leaf total chlorophyll (58.43 and 60.92) in both seasons respectively. On the contrary, untreated trees T_1 gave the lowest leaf area (2.56

cm^2 and 2.25 cm^2) and leaf total chlorophyll (36.22 and 37.95) in both seasons.

The positive effect of salicylic acid on growth may be due to its effect on plant hormones **(Shakirova, 2007).** Salicylic acid increased leaf chlorophyll content (**Abdel Aziz et al., 2017)**. Additionally, it can influence stomatal movement, photosynthesis, ethylene production, plant water relations, and the ability of ABA to reverse the effects of leaf abscission **(Arfan et al., 2007)**. **Abd El-Naby et al. (2020)** spraying SA at a high concentration shows a positive effect on vegetative growth characteristics of the navel orange. **Mokhtar et al. (2011)** observed varying concentrations of SA (50 to 400 ppm) and frequencies (1, 2, 3, or 4 times) with a gradual promotion in the leaf area. **Hamdy et al. (2019)** Spraying SA at 50 to 200 ppm improved all vegetative growth aspects, leaf chlorophyll contents on fig trees. **Ahmed et al. (2015)** showed that using salicylic acid at 50 to 200 ppm enhanced shoot length, leaf area, and total chlorophylls on mango , these lead to more carbohydrate production and this is reflected in fruit quality.

It is also could be due to the biomagic contents of proteins, amino acids, vitamins, and hormones, as well as some micronutrients, growth regulators, and vitamins which enhanced cell division, metabolism, and other biological reactions .In addition to the activation effect of these components on photosynthesis and promoting protoplasm formation including RNA and DNA that are important for cell division, All of these materials lead to reducing the impact of stress on the plant **(El Massiry, 2009; Ibrahim, 2009; El-Hifny and El-Sayed ,2011and Hashem ,2016).**

The obtained results regarding the effect of salicylic acid on fruit quality go in line with the findings of **(Abdel Aziz et al., 2017** and **Amro et al., 2020)** on pomegranate fruits.**(Khedr and Farid, 2000;; El Massiry, 2009, and Ibrahim, 2009)** who reported that biomagic improved growth. In addition, **Abd El-Hamied (2014a&b)** stated that the addition of bio-fertilizers increased vegetative growth measurements of mango.

Table.4: Effect of spraying salicylic acid and Biomagic on leaf area and leaf total chlorophyll (SPAD)of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	Leaf area cm^2		leaf total chlorophyll (SPAD)	
	Season 2020	Season 2021	Season 2020	Season 2021
T_1	2.56i	2.25i	36.22i	37.95i
T_2	2.47h	2.61h	38.57h	40.01h
T_3	3.06g	2.97g	41.53g	42.36g
T_4	3.54f	3.35f	44.49f	44.01f
T_5	3.93e	3.83e	47.87e	48.15e
T_6	4.37d	4.29d	50.16d	49.71d
T_7	4.57c	4.93c	53.51c	54.43c
T_8	5.28b	5.6b	56.61b	57.31b
T_9	5.96a	6.13a	58.43a	60.92a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%,(T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l.

Fruit length (cm), fruit diameter (cm), and fruit weight (g)

Data in table (5), shows that fruit length, fruit diameter, and fruit weight were significantly affected by all treatments in both seasons. However, T_9 gave the highest fruit length, fruit diameter, and fruit weight in the 1st and the 2nd seasons. On the other hand, the untreated trees T_1 gave the lowest fruit length, fruit diameter, and fruit weight in both seasons.

Table.5.:Effect of spraying salicylic acid and Biomagic on fruit length(cm) ,fruit diameter(cm) and fruit weight(g) of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	Fruit length (cm)		Fruit diameter (cm)		fruit weight (g)	
	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021
T_1	7.51 e	7.57 e	7.40 f	7.52 g	349.22 g	351.84 g
T_2	7.61 de	7.69 d	7.58 f	7.73 f	355.88 f	357.29 f
T_3	7.73 cde	7.77 cd	7.89 e	7.92 e	362.12 e	364.44 e
T_4	7.75 bcd	7.79 cd	7.94 de	8.02 e	367.61 d	368.07 e
T_5	7.79 abc	7.83 c	8.10 d	8.20 d	373.14 c	375.45 d
T_6	7.81 ab	7.88 c	8.32 c	8.48 c	376.67 b	377.45 cd
T_7	7.89 ab	8.02 b	8.54 b	8.67 b	379.33 a	381.54 bc
T_8	7.92 a	8.13 b	8.76 a	8.72 b	380.15 a	385.05 b
T_9	7.94 a	8.33 a	8.80 a	8.96 a	380.99 a	400.11 a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%,(T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Fruit grains weight (g) and grains/fruit weight percentage

Concerning the results in Table 6, fruit grains weight (g), and grains/fruit weight % were significantly affected by all treatments in both seasons. However, T_9 gave the best fruit grains weight (g) (303.13 and 311.33 (g) and grains/fruit weight percentage (79.56 and 77.81%) in 1st and 2nd season respectively. On the other side, T_1 gave the lowest fruit grains weight (g) and grains/fruit weight percentage in both seasons.

Table.6: Effect of spraying salicylic acid and Biomagic on fruit grains weight(g)and grains/fruit weight %of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	Fruit grains weight (g)		Grains/fruit weight %	
	Season 2020	Season 2021	Season 2020	Season 2021
T_1	219.44 i	221.81 h	62.84 i	63.04 i
T_2	227.78 h	231.26 g	64.00 h	64.73 h
T_3	238.25 g	246.42 f	65.79 g	67.62 g
T_4	256.77 f	259.59 e	69.85 f	70.53 f
T_5	264.11 e	268.37 d	70.78 e	71.48e
T_6	276.46 d	280.67 c	73.40 d	74.36d
T_7	285.33 c	289.11 b	75.22 c	75.77c
T_8	291.48 b	295.83 b	76.67 b	76.83b
T_9	303.13 a	311.33 a	79.56 a	77.81a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%,(T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Number of fruits/tree and total yield/tree (Kg)

It is shown from the data in table (7) that the number of fruits /tree and total yield /tree (kg) were significantly affected by all treatments in both seasons. In addition, T_9 gave the best number of fruits and the total yield in both seasons respectively. On the other hand, T_1 gave the lowest number of fruits and total yield in both seasons.

The number of fruits and total yield were affected significantly by spraying trees with salicylic acid in combination with biomagic in both seasons. It is observed that spraying the solo concentrations of salicylic acid and biomagic recorded less number of fruits and total yield (kg) in the 1st and the 2nd season respectively.

The increase in the number of fruits by salicylate treatments could be due to: an increased flowering rate, set fruits, or a decrease in fruit abscission. An increase in plum tree yield has been recently reported as a consequence of salicylate treatments, although it was due to increased fruit mass but not the number of fruits. **(Martínez et al., 2018).** SA activates growth and the nutritional state of trees due to an increase in fresh and dry weight and chlorophyll, carotenoid, and sugar concentration in leaves, which illustrates an enhancement of net photosynthesis on trees **(Helaly et al., 2018**). The positive effect of SA on yield may be due to its effect on plant hormones (**Shakirova, 2007). Hamdy et al., (2019**) found that different concentrations of SA represented varying effects on the yield of fig tree.

These results were in agreement with **Amro et al. (2020)** found that salicylic treatments enhanced the yield of pomegranate var "wonderful". **Mokhtar et al (2011)** sprayed Anna apple trees with salicylic acid at 200 ppm three times (at growth start, just after fruit set, and at 14 days later) giving an economical yield. In addition, using salicylic acid was very effective to improve the yield of fruits (**Ahmed and Abd El-Hameed, 2004; Ibrahim-, 2006; Imran et al., 2007; Abd El-Kariem, 2008 and Ahmed et al., 2010). Abd El-all and Fouad (2019**)said that SA improved yield (kg/tree) , and number of fruits/tree. **Ying-Ning et al. (2014**) revealed that the applications of SA decreased the flower dropping percentage and increased the fruit setting percentage on citrus. **Ahmed et al (2015)** said that Sukkary mango trees' yield was increased by two sprays of salicylic acid at 100 ppm at the beginning of growth and after fruit set. **Helaly et al., (2018**) they found a higher percentage of fruit retention and crop yield on two mango cultivars using SA treatments. In addition, Bio-fertilizers are the most important for plant production, they play an important role in increasing yield **(Soliman, 2001**) on guava and banana plants and (**Osman et al., 2010)** on olive plants, (**Chokha et al., 2000; El-Geuoshy, 2011 and Bakry et al., 2013**) on sweet orange. **Abd El-Hamied (2019**) proved that biomagic was very effective on yield (number of fruits and fruit weights) for the final crop.

Table.7: Effect of spraying salicylic acid and Biomagic on No of fruits/tree and total yield /tree(kg) of "Manfalouty`" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	No of fruits/tree		Total yield /tree (kg)	
	Season 2020	Season 2021	Season 2020	Season 2021
T_1	37.80 f	39.11e	13.21 g	13.76 f
T_2	39.06 ef	39.66 e	13.93 f	14.17 f
T_3	39.21 ef	40.53 de	14.22 f	14.77 e
T_4	40.80 de	41.57 cd	15.00 e	15.30 d
T_5	41.81 cd	42.80 bc	15.62 d	16.07 c
T_6	41.68 cd	44.43 ab	15.74 d	16.77 b
T_7	42.71bc	44.03 ab	16.20 c	16.80 b
T_8	44.19ab	44.59 ab	16.81 b	17.17 b
T_9	45.41a	45.41 a	17.32 a	18.17 a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%,(T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Total soluble solids percenrage(T.S.S.%), total sugar%, vitamin C (mg/100g pulp) and total acidity%

Data in table (8), showed, that total soluble solids percentage(T.S.S.%), total sugar%, vitamin C and total acidity% were significantly affected by all treatments in both seasons. However, T_9 gave the highest total soluble solids, total sugar%, vitamin C and the lowest total acidity%. On the other hand, the T_1 treatment gave the lowest T.S.S%, total sugar%, vitamin C and the highest total acidity %in both seasons.

The obtained results regarding the effect of salicylic acid on fruit quality go in line with the findings of **Abdel Aziz et al.(2017**) on pomegranate fruits. **Hamdy et al. (2019**) Increasing SA concentration resulted in a gradual and significant promotion in T.S.S. %, increasing sugars %, and decreasing total acidity % in fig tree, the frequency of application of SA from one to three times improve the fruits' physical properties. **Ahmed et al. (2015)** proved that fruit quality of Sukkary mango trees was improved by two sprays of salicylic acid at 100 ppm at the beginning of growth and after fruit set. In addition **.Amro et al. (2020)** found that salicylic treatments enhanced fruit quality traits of pomegranate "wonderful". Salicylic acid was very effective in improving the physical characteristics of fruits in different fruit crops (**Ahmed and Abd El-Hameed, 2004; Ibrahim, 2006; Imran et al., 2007; Abd El-Kariem, 2008** and **Ahmed et al., 2010)**. **Mirdehghan, et al. (2012**) and (**Zhang et al., 2003)** found that spraying salicylic acid reduces the total acidity% and increases TSS of pomegranates**. Abd El-all and Fouad (2019**) SA improved yield (kg/tree), fruit weight (g), number of fruits/tree, T.S.S., TSS /acid % ratio, and reduced acidity %. Furthermore, Bio-fertilizers are the most important for plant production and soil as they play an important role in increasing fruit quality (**Soliman,2001**) in guava and banana plants and (**Osman et al., 2010**) in olive plants, **(Chokha et al., 2000; El-Geuoshy, 2011 and Bakry et al., 2013)** on sweet orange. **Abd El-Hamied (2019)** proved that biomagic was very effective on fruit chemical characteristics of fig tree.

Table.8: Effect of spraying salicylic acid and Biomagic on fruit Total soluble solids percentage(T.S.S%.), total sugar%, vitamin C(mg/100g pulp) and total acidity% of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	T.S.S.%		Total sugar%		Vitamin C (mg/100g pulp)		Total acidity %	
	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2020	Season 2020	Season 2021
T_1	14.12 h	14.28 h	12.10 f	12.40 f	14.41i	14.41i	0.42 a	0.43 a
T_2	14.33 g	14.63 g	12.21 f	12.65 ef	14.74h	14.74h	0.41 ab	0.41 ab
T_3	14.75 f	14.96 f	12.45 e	12.83 e	15.08g	15.08g	0.40 abc	0.38 abc
T_4	15.42 e	15.51 e	12.99 d	13.15 d	15.28f	15.28f	0.39 abc	0.37 bc0
T_5	15.73 d	15.78 d	13.01 d	13.29 d	15.42e	15.42e	0.38 abc	0.37 bc0
T_6	15.97 c	16.17 c	13.58 c	13.77 c	15.62d	15.62d	0.37 abc	0.35 cd
T_7	16.21 b	16.27 bc	14.05 b	14.23 b	15.86c	15.86c	0.36 bc	0.34 cde
T_8	16.35 ab	16.48 b	14.28 a	14.44 b	15.97b	15.97b	0.35 c	0.32 de
T_9	16.49a	16.78 a	14.24 a	14.81 a	16.65a	16.65a	0.35 c	0.30 e

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%,(T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l.

Fruit cracking % and Sunburned fruit (%)

Table 9, cleared that cracking and sunburn percentage of fruits were significantly affected by all treatments in both seasons. However, T_9 treatment gave the lowest cracking (14.17 % and 13.7%) and sunburn (9.00% and 7.87%) in both seasons respectively. On the other hand, T_1 gave the highest cracking (30.30 % and 28.46%) and sunburn (18.40% and 16.40%) in both seasons.

The positive effect of salicylic acid in reducing cracked and sunburned fruits may be attributed to salicylic

acid playing a crucial role in keeping cells from ageing and stopping free radicals from oxidizing lipids, which make up the plasma membrane, which may explain why it has a favorable impact on reducing cracked and sunburned fruit. Salicylic acid helps the body's antioxidant system, which also helps with stress management. It is in charge of boosting naturally occurring hormones that are essential for controlling plant growth and development, as well as the production of IAA, and limiting the detrimental effects of various stresses on plant development. **(Senarataa et al., 2004**). Salicylic acid has a significant role in plant water relations, photosynthesis, and growth in plants (**Arfan et al., 2007**), and this is reflected on reducing cracked and sunburned fruits.

The obtained results regarding the effect of salicylic acid on fruit disorders go in line with the findings of **Ahmed et al. (2014)** on pomegranate, **Abdel Aziz et al. (2017**) on pomegranate and **Amro et al. (2020)** on pomegranate.

Table.9: Effect of spraying salicylic acid and Biomagic on fruit cracking% and sunburned fruit% of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	Fruit Cracking%		Sunburned fruit (%)	
	Season 2020	Season 2021	Season 2020	Season 2021
T1	30.30a	28.46a	18.40a	16.40a
T2	27.30b	26.37b	17.33b	15.37b
T3	25.50c	24.47c	15.63c	14.7c
T4	24.43c	23.23d	14.53d	13.20d
T5	22.47d	21.57e	13.43e	12.4e
T6	20.40e	19.63f	12.53f	11.37f
T7	18.60f	22.80g	11.00g	10.60g
T8	16.67g	17.477h	10.33h	9.30h
T9	14.17h	13.7i	9.00i	7.87i

Means having the same letter (s) in each column is not significantly different at 5% level.
(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%,(T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l.

IV. CONCLUSION

It could be concluded that spraying pomegranate with salicylic acid 200 ppm + biomagic 8.5cm/l gave the best vegetative growth, fruit physical, chemical properties, and gave the lowest total acidity, fruit cracking percentage, and sunburn percentage under heat stress in Siwa oasis.

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Trees Outside Forests in Tamil Nadu, India – An Overview

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Abstract— *The tree resource outside the forest (TOF) is a highly diverse and locally different natural renewable resource. In many regions they play a prominent role in securing rural livelihoods viz., provision of small timber, firewood, fodder, fruits, medicinal value, etc. Agroforestry systems are multifunctional systems that can provide a wide range of economic, socio cultural and environmental benefits. Agroforestry can be particularly important for smallholder farmers because it generates diverse products and services on a limited land area. Agroforestry practices in Tamil Nadu (TN), India, have existed since time immemorial and are evidenced in all parts of the state with less or no scientific management. Agroforestry research is a new field that is getting momentum in recent times due to popularization of industrial agroforestry. In the present context, to meet the national target of forest cover (33%) and to reduce pressure on natural forests, agroforestry plays a vital role and provides additional income to the farming community. This article aims to provide an insight into agroforestry practices in TN, including reasons for opting them, problems faced, etc. It also provides information on agroclimatic zone-wise tree species and agroforestry systems being practised by farmers.*

Keywords— ***Forests, agroforestry models, ToF.***

I. INTRODUCTION

Trees outside forests (ToF) in India, mainly growing on private land, are the main source of wood in the country for industry and domestic wood fuel. Growing trees outside forests (ToF) presents a significant environmental and economic opportunity in India. India has several enabling policies and schemes that embed a range of monetary and non-monetary incentives for scaling up ToF through interventions such as agroforestry. Key benefits include improved livelihoods, jobs and income generation, enhanced soil health, biodiversity conservation, carbon sequestration, and increased resilience of local communities (GoI, 2014). The National Agroforestry Policy (2014) of India, which was the first of its kind in the world, has identified several strategies to promote agroforestry in India. In India, there is a scope for ToF/agroforestry in an area of over 50 M ha which can provide food, fuel wood, fodder, and non-timber forest produce (NTFP) by planting of multipurpose trees. India has several enabling policies and schemes embedding a range of monetary and nonmonetary incentives for the scaling of ToF through interventions such as agroforestry. India has several enabling policies and schemes embedding a range of monetary and nonmonetary incentives for the scaling of ToF through interventions such as agroforestry (Duraisamy *et al.*, 2022). TOF not only provides environmental services, but also economic gains, as about 65% of the country's timber requirement is met from the trees grown outside forests (Dhillon *et al.*, 2018).

As of now about 25 M ha area is under Agroforestry land use in India and supports almost half of the demand of fuel wood, two third of small timber, 70-80% wood for plywood industry, 60% raw material for paper pulp and 9-

11% of green fodder requirement of livestock. Although, current average biomass productivity in India is less than 2 $tha^{-1}yr^{-1}$ but it can be enhanced to 10 $tha^{-1}yr^{-1}$through careful selection of compatible tree crop combination not only to bridge the gap in demand and supply but also to make country surplus in plywood, paper pulp and small timber. Deep tree roots also help prevent soil erosion. Agroforestry systems can also be used as carbon sinks within an environment, and to an extent, help counter the effects of continued deforestation on the carbon cycle. The productivity of trees outside forests is very high in comparison to natural forests and in-addition trees grown have market demand. TOF supplies approximately 49% of the fuel wood and 48% of the timber annually (Rai and Chakraborty, 2001). With too high productivity, it may be assumed that an area of 3 m ha planted with superior material with rotation of 8 yrs can meet all the national wood demands. There are several challenges that impede implementation, such as lack of quality planting material; technical capacity and knowledge gaps; market and finance gaps; and inadequate attention to issues around land and tree tenure, gender, and social inclusion (ICFRE 2020).

This paper deals with the choice of species preferred by the farmers, existing tree species in the farm fields of Tamil Nadu, reasons for opting tree species in farm lands, constraints faced by the farmers in ToF, etc. are discussed in detail.

II. MATERIALS AND METHODS

Study area: This study was conducted in Tamil Nadu and it is a very important cultural center and its geographical coordinates are 11.1271 N and 78.6568 E. Tamil Nadu is mostly dependent on monsoon rains and thereby is prone to droughts when the monsoons fail. The climate of the state ranges from dry sub-humid to semi-arid. The state has two distinct periods of rainfall viz., South west monsoon from June to September, with strong southwest winds and North east monsoon from October to December, with dominant northeast winds. The annual rainfall of the state is about 945 mm. Mean annual maximum temperature for Tamil Nadu is 32.2º C and mean annual minimum temperature is 22.6º C. The predominant soils of Tamil Nadu are red loam, laterite, black, alluvial and saline soils.

Sampling procedure and Survey method: A questionnaire was prepared for collecting information from the study area of different districts of Tamil Nadu. Using this questionnaire, relevant information was collected from 1500 farmers, comprising each 500 of marginal, medium and large farmers' category which were randomly selected from the study area. Data were recorded from these selected farmers from June - December, 2022. In conformity with the set objectives of the study, a set of preliminary survey schedules has been designed for collection of data for the study. Thus, the final survey schedule has been prepared in a simple manner maintaining logical sequences and necessary adjustments.

Data analysis: The collected data was analysed by 'Garrett scoring Technique' (Garrett and Woodworth, 1969) and presented in the results and discussion part.

III. RESULTS AND DISCUSSIONS

1. Tree species maintained under ToF in Tamil Nadu

During the survey it was recorded that, more than 30 tree species are being planted and maintained under ToF in Tamil Nadu. Farmers are planted the tree species mainly for timber, small timber, NTFP, green manure, fuel wood, fodder, fruits and raw material for wood based industries (Table-1). Among different uses, maintaining for NTFP scored 32% followed by timber purpose (26%), green manure (19%) and least for fuel wood and medicine (3%).

Farmers in TN are practising ToF mainly to meet their day-to-day needs and for economic upliftment. The trees which are commonly grown under agroforestry in TN are *Ailanthus excelsa*, *A. lebbeck*, *Delonix alata*, *Tectona grandis*, *Pongamia pinnata*, *Azadirachta indica*, *Tamarindus indica*, *Thespesia populnea*, *Tamarindus indica*, *Mangifera indica*, *Achras zapota*, *Emblica officinalis*, *Sesbania grandiflora*, *Syzygium cumini*, *Eucalyptus*, *Acacia leucophloea*, *Casuarina equisetifolia*, *Pithecellobium dulce*, *Ailantus exelsa*, *Albizia lebbeck*, *Bamboo*, etc. Teak is an important timber species commonly found in farm bunds (Teaknet, . *A. lebbeck* is an important fast-growing tree mostly found in bunds in the state, having multi-utility for making moulds, in the carving industry, etc. (Kannan, 2010) Trees like neem and pungam are commonly planted mainly for medicinal and small timber purposes (Prabakaran *et al.,* 2019). Horticultural species like mango, guava, banana, sapota, amla, papaya pomegranate, lemon, etc. are considered as an ideal option and are common in all the agro-climatic zones of TN. The climatic and edaphic factors are favourable for fruit tree cultivation. Integration of horticultural species in farmlands helps in efficient utilization of natural resources and generates adequate income, provides employment and improves livelihood.

ToF emerges as an effective tool for improvement of the rural economy due to low investment, high profitability and high income-generating practices. Numerous agroforestry systems and combinations of annual crops are

practised by the farming community in TN and many multipurpose trees are found compatible in various agro-climatic regions of the state. Trees like teak, *Casuarina*, sandal, *Ailanthus*, bamboo, amla, etc. are among the most suitable species, which can be grown under ToF with minimal crop yield reduction. Appropriate tree–crop arrangements can indicate which combination is better in terms of profitability and acts as a feasible option that provides livelihood security to the rural community with less supervision and inputs. These ToF combinations and systems help increase the economy of the farmers, provide food security and make them self-sufficient. The ecosystem services generated from ToF adoption will help ameliorate the micro-climate of farmlands to promote climate-resilient crops. These ToF programmes will be an effective tool for climate mitigation and adaption mechanism to counter climate change, and act as a sink for greenhouse gases (Dobriyal *et al.,* 2012). Table-3 indicates that non-availability of agricultural labour (ranked first in four agro-climatic zones) and higher returns from tree components (ranked first in two agro-climatic zones) registered higher mean score and ranked among other reasons for adoption of agroforestry systems in different agro-climatic regions of TN. The other important reasons are less attention needed for tree species, less risk and fewer inputs compared to crops. Apart from the above reasons, climatic vagaries also play a vital role in the adoption of agroforestry systems among farmers throughout the state (Saravanan, 2017).

Jambulingam and Fernandus (2005) reported that, farmers in TN State integrate numerous species of multipurpose trees and shrubs on their farmlands in close association with agricultural crops and/or livestock. The dominant among them are *Borassus flabellifer, Tamarindus indica, Ceiba pentandra, Acacia leucophloea* and *A. nilotica*. These woody perennials are better able to cope with poor growing conditions. Their increasing integration on farmlands represents a strategy to minimise risk of crop failure. Some species (e.g. *Prosopis juliflora* and *Delonix elata*) are deliberately used to ameliorate infertile or saline soils in order to permit the growing of annual crops. In addition to producing fuel wood, charcoal, fruit and fodder and providing many service functions, these species require only fewer inputs and give the farmer a choice of management options in the event of poor crop growth. Farmers in TN State integrate numerous species of multipurpose trees and shrubs on their farmlands in close association with agricultural crops and/or livestock. The dominant among them are *Borassus flabellifer, Tamarindus indica, Ceiba pentandra*, *Acacia leucophloea* and *A. nilotica*. These woody perennials are better able to cope with poor growing conditions. Their increasing integration on farmlands represents a strategy to minimise risk of crop failure. Some species (e.g. *Prosopis juliflora* and *Delonix elata*) are deliberately used to ameliorate infertile or saline soils in order to permit the growing of annual crops. In addition to producing fuel wood, charcoal, fruit and fodder and providing many service functions, these species require only fewer inputs and give the farmer a choice of management options in the event of poor crop growth.

Jharia *et al.*,(2013) also reported that, other than *Eucalyptus*, some other MPTs including *Terminalia arjuna*, *Terminalia tomentosa*, *Albizia procera*, *Mangifera indica*, *Butea monosperma*, *Zizyphus mauritiana*, *Azadirachta indica* and *Gmelina arborea* are also planted in the farm bunds. Farmers of Gujarat preferred and retains tree species of *Acacia nilotica, Acacia catechu, Dalbergia sissoo, Mangifera indica, Zizyphus mauritiana* and *Gmelina arborea* along with crops. In Bihar, *Dalbergia sissoo, Litchi chinensis* and mango are frequently grown on field, but for boundary plantation, *Sissoo* and *Wendlandia exserta* are most commonly used. Farmers of Sikkim, grow bamboo species (*Dendrocalamus strictus*, *Bambusa bambos*) all along the irrigation channels (Jhariya *et al.,* 2015). Pohjonen and Pukkala (1990) revealed that, *Eucalyptus globulus* trees are unpalatable to goats, sheep and cattle, thus they have a distinct advantage as boundary planting in Ethiopia.

2. Types of ToF Systems preferred by farmers of Tamil Nadu

During the survey, it was observed that, most of the farmers (45%) are interested to maintain the trees under agroforestry models compared to under bund planting (32%), home gardens (15%) and least in other forms (8%) (Fig-1). Also, it was observed that, 36% of farmers are interested in maintaining ToF for supply of raw material for wood based industries. Mostly farmers are interested in planting of *Casuarina, Eucalyptus, Melia dubia, Ailanthus excelsa*, *Neolamarckia cadamba*, *Gmelina arborea*, etc. under block plantation as a raw material for wood based industries followed by timber purpose (28%), small timber (11%), fodder (10%), green manure (8%) and least for NTFP purposes (7%) (Fig-2).

The ToF in TN has received significant attraction due to the participation of various wood based industries like pulp and paper, match, plywood, biomass power and timber which resulted in development of massive plantation development programme. The pulpwood based ToF model has prioritized only two species viz., Casuarina and Eucalyptus. Wood based industries promoting through contract farming with minimum support price for the wood produced from ToF and at present the pulpwood

based industrial ToF model covered more than a lakh ha area covering about 75,000 farmers (Parthiban and Cinthiya Fernandaz, 2017). During the survey, about 28% of the farmers are interested in growing trees species of timber value and facing some issues like non availability of quality planting material, felling and transportation, etc. This is in tune with Ghosh Mili Sinha Bhaskar (2018) revealed that the potential of ToF for timber production is not being realized due to the absence of a uniform nationwide policy related to management, harvest, transit and marketing of timber from ToF. We further describe how the ambiguity and cumbersome nature of existing policies pose as constraints for farmers who want to grow and benefit from ToF.

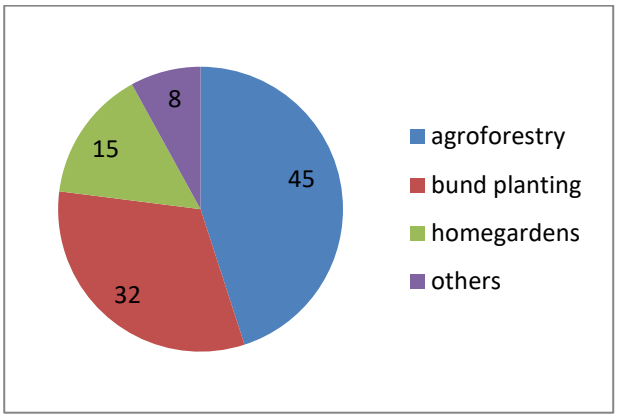

Fig-1. Types of ToF preferred by the farmers of Tamil Nadu

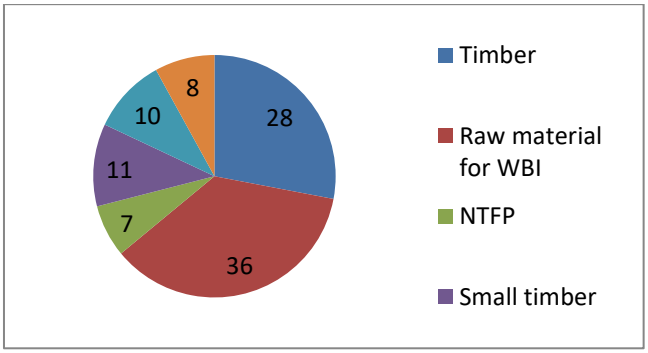

Fig-2. Species preferences under ToF in Tamil Nadu

3. Reasons for opting ToF in Tamil Nadu

The reasons were obtained from farmers and ranked based on 'Garrett scoring Technique' and presented in Table-2 & 3 and Fig.2. During survey, reasons were given to farmers and asked them to rank for opting ToF. The farmers were classified in to marginal, medium and large farmer category and noted the reasons for maintaining trees under ToF. Marginal farmers expressed that, meeting their daily needs from trees ranked 1st followed by higher income and future investment with the mean score of 59.84, 56.24 and 54.81 respectively. Least score of 47.13 was given for the last rank with the reason for efficient land utilization. Medium farmers are expressed that, higher income is the prime reason for maintaining trees in farm bunds with the mean score of 60.42 followed by future investment and promotion of ToF with the mean score of 58.36 and 54.68 respectively. Least score was given to efficient land utilization with the mean score of 49.81. With reference to large farmers' category, future investment recorded 1st reason for adoption of bund planting with the mean score of 62.56 followed by higher income (59.61) and promotion of ToF (55.71). Meeting day to day needs reason registered least score of 45.47 in large farmers' category. Bargali *et al.*, (2004) reported that, small landholders preferred only bamboo and Eucalyptus for bund and boundary plantations to meet their household requirements. Medium and large farmers preferred a number of species as they are into commercial production and they have better resources in the state of Chhattisgarh. Depommier *et al.*, (2002) articulated that the needs and strategies of small farmers usually correspond to subsistence agriculture with low inputs and, interestingly, a high level of diversification, which includes tree products and services. The multipurpose use of species partly satisfies the basic needs of poor farmers. Saravanan (2021) revealed that, non-availability of agricultural labour (ranked first in four agro-climatic zones) and higher returns from tree components (ranked first in two agro-climatic zones) registered higher mean score and ranked among other reasons for adoption of agroforestry systems in different agro-climatic regions of Tamil Nadu.

4. Level of domestication and extent of adoption of ToF in Tamil Nadu

The main determinants of adoption were age of farmers, household size, educational level, farm size, farming experience, income, access to credit and extension contacts. All these variables, except age of farmers, affected the adoption rate of agroforestry technologies positively (Sangeetha *et al.*, 2016). The level of domestication and extent of adoption of agroforestry (Table 4) reveals that farmers are well aware of the type and quality of planting materials and they prefer quality planting materials especially high-yielding clones which will give more productivity than seed-source seedlings. They are also knowledgeable about intercropping activities and size of pits for various tree components, including horticultural species. Also, they give equal importance for weeding and time of planting which is important for the establishment of tree components; it also reduces irrigation cost. Table 4 reveals that farmers are less attentive towards soil working, mulching and plant protection measures;

they consider, these activities to be non-remunerative and as adding more cost in the maintenance of agroforestry systems.

5. Constraints faced by the farmers in adoption of ToF

The major constraints faced by the tree-growing farmers are presented in Table-5. These are divided into five major categories, *viz.* labour, inputs, technology, marketing, loan/credit and others. It shows that, non-availability of agriculture labour and their wages play a vital role in the adoption of tree farming. For tree farming-related activities, farmers can manage with a few labourers when it is necessary. Non-availability of quality planting materials or difficulty in accessing them also plays a major role and farmers depend mostly on local nurseries for planting stock, normally poor in quality, which will not give good returns in the future. Farmers also face constraints in the application of fertilizers and protection measures for tree components. Unlike in agriculture, for tree species, no or little information is available on establishment and management strategies (precision silvicultural techniques). This leads to poor management of the tree components resulting in yield and returns. Also, forestry extension strategies are not clear and reached among farmers compared to agriculture extension activities. Both aspects need to be strengthened for the welfare of tree-growers and greater adoption of tree farming. One of the major problems faced by the tree growers is the non-availability of loan (for establishment and maintenance period) and insurance (during crop failure due to biotic, abiotic factors and climate vagaries) facilities. Further, non-availability of marketing structure, linkage with other stakeholders, etc. are also major constraints faced by tree growers. We need to address the above problems for greater adoption of tree farming and higher economic returns to the farming community. Sangeetha *et al.*, (2016) revealed that, lack of QPM is viewed as the most critical constraint faced by famers in the adoption of agroforestry species with 3.62 mean rank followed by the lack of capital with mean rank of 3.21.

6. Strategies and challenges in the promotion of agroforestry in TN

ToF is playing a vital role in maintaining natural resources and increasing overall productivity with minimizing risk against the vagaries of weather. Multipurpose tree species are the choice to integrate with annual crops/vegetables/ medicinal plants or with grasses. Although agroforestry is practised in India since ancient times, it has not gained importance due to dependency on multi-institutions and multi-disciplinary approach (Dhyani and Handa, 2014). The NAP-2014 has indicated the way forward to promoting ToF among various stakeholders. There should be proper coordination between various stakeholders of ToF like researchers, extension workers, industries, farmers etc. India is a land of variability in terms of climate, soil, etc. Hence location-specific and economically sound agroforestry systems need to be developed. Agroforestry land use has great potential in providing ecosystem services; hence, these services should be quantified as accurately as possible. The sustainable land-use system approach is required at this juncture to overcome uncertainty of the monsoon and frequent natural calamities, and to maintain food security. Usually, lack of scientific knowledge, institutional approach and negative attributes of tree components (viz. long rotation, shade effect, opportunity cost, etc.) discourage farmers from adopting tree farming. However, recent developments in the production, processing and consumption sectors have generated interest among farmers to adopt agroforestry systems holistically for higher economic returns. The present probable area under agroforestry in India is estimated to be 25.32 m ha, or 8.2% of the total geographical area of the country (Dhyani, 2014). Despite encouragement for growing trees on farmlands, the farmers of TN have to deal with many constraints and limitations related to agroforestry. The difficulty in felling, harvesting, transit pass and marketing (rights on cutting and selling of wood), and insecure regulation discourage them to cultivate trees.

IV. CONCLUSION

We are in the era to feed various stakeholders such us people, wood based industries, etc. Practising of agriculture alone will not fulfil the small and marginal farmers' needs due to climatic vagaries, increasing pressure on practising agriculture, declining size of land holdings and conversion of agricultural land to non agricultural purposes. To overcome these problems, agroforestry is a solution that will improve the livelihood of the farming community through cluster approach and value chain models by bringing all the stakeholders under one common platform. Incorporation of trees/livestock within the farmlands will generate adequate income and generate rural employment (approximately 145 man day's ha^{-1}). The central and state government research institutions, SFD and wood-based industries are promoting agroforestry and farm forestry at a large scale in TN with precision silvicultural techniques and assured price mechanism. These initiatives will not only fulfil the domestic and economic needs of the farmers, but also provide several environmental benefits. Moreover, promoting ToF by the merging of various ongoing central and state government schemes, will give a boost to the

farmers and bring more area under tree cover (agroforestry). Finally, agroforestry practices are needed to maintain the natural (forest) resources and agrarian identity at the national level.

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Table-1: List of tree species planted and maintained under ToF in Tamil Nadu

Tree species	Family	Main uses								
		Timber	Small timber	NTFP	Green manure	Medicine	Fuel wood	Fodder	Fruits	WBI
Casuarina equisetifolia	Casuarinaceae	--	--	--	--	--	*	--	--	*
Tectona grandis	Lamiaceae	*	--	--	--	--	--	--	--	--
Azadirachta indica	Meliaceae	--	*	*	*	--	--	--	--	--
Pongamia pinnata	Fabaceae	--	--	*	*	*	--	--	--	--
Lannea coromendalica	Anacardiaceae	--	--	--	*	--	--	*	--	--
Eucalyptus spp.	Myrtaceae	--	--	--	--	--	--	--	--	*
Thespesia populnea	Malvaceae	--	*	--	--	--	--	*	--	--
Ceiba pentandra	Malvaceae	--	--	*	--	--	--	--	--	--
Ailanthus excels	Simaroubaceae	--		--	--	--	--	--	--	*
Albizia lebbeck	Fabaceae	--	*		*	--	--	--	--	--
Borasus flabellifer	Arecaceae		--	*	--	--	--	--	--	--
Mangifera indica	Anacardiaceae	*	--	--	--	--	--	--	*	--
Emblica officinalis	Phyllanthaceae	--	--	*	--	--	--	--	--	--
Delonix alata	Fabaceae	--	--	--	*	--	--	*	--	--
Tamarindus indica	Fabaceae	--	--	*	--	--	--	--	--	--
Sesbania grandiflora	Fabaceae	--	--	--	*	--	--	--	--	--
Bamboo spp.	Poaceae	--	*	--	--	--	--	--	--	--
Santalum album	Santalaceae	--	--	*	--	--	--	--	--	--
Melia dubia	Meliaceae	--	--	--	--	--	--	*	--	*
Neolamarckia cadamba	Rubiaceae	--	--	--	--	--	--	--	--	*
Gmelina arborea	Verbenaceae	*	--	--	--	--	--	--	--	--
Pterocarpus santalinus	Fabaceae	--	--	*	--	--	--	--	--	--

Anacardium occidentale	Anacardiaceae	--	--	--	--	--	--	--	*	--
Pterocarpus marsupium	Fabaceae	*	--	--	--	--	--	*	--	--
Dalbergia sissoo	Fabaceae	*	--	--	--	--	--	--	--	--
Dalbergia latifolia	Fabaceae	*	--	--	--	--	--	--	--	--
Haldina cordifolia	Rubiaceae	*	--	--	--	--	--	--	--	--
Swietenia macrophylla	Meliaceae	*	--	--	--	--	--	--	--	--
Syzygium cumini	Myrtaceae	--	--	*	--	--	--	--	--	--
Artocarpus hetrophyllus	Moraceae	--	--	--	--	--	--	--	*	--
Callophyllum innophyllum	Calophyllaceae	--	--	*	--	--	--	--	--	--

WBI = Wood Based Industries

Table-2: Reasons for opting ToF in different farmers categories of Tamil Nadu

Reasons	Marginal farmers		Medium farmers		Large farmers	
	Mean score	Rank	Mean score	Rank	Mean score	Rank
Meeting day to day needs	59.84 (1100*) 74%	I	52.83 (800) 53.3%	V	45.47 (679) 45.3%	VI
Higher income	56.24 (1035) 69%	II	60.42 (1189) 79.3%	I	59.61 (1050) 70%	II
Future investment	54.81 (960) 64%	III	58.36 (1120) 74.7%	II	62.56 (1189) 79.3%	I
Less risk and inputs	52.56 (930) 62	IV	57.45 (880) 58.7%	IV	48.25 (761) 50.7%	V
Promotion of ToF	49.63 (840) 56	V	54.68 (970) 64.7%	III	55.71 (970) 64.7%	III
Efficient land utilization	47.13 (720) 48	VI	49.81 (720) 48%	VI	52.37 (851) 56.7%	IV

* Value within brackets are frequency (n = 1500)

Table-2: Reasons for chosing ToF in different agro-climatic zones of Tamil Nadu

Reasons	North Eastern zone		North western zone		Western zone		Cauvery delta zone		Southern zone	
	Mean score	Rank	Mean score	Rank	Mean score	Rank	Mean score	Rank	Mean score	Rank
Non availability of agricultural labour	56.64 (1290)*	I	57.61 (1230)	I	58.56 (1290)	II	57.81 (1230)	I	56.08 (1170)	III
Higher income from tree component	55.42 (1170)	II	56.32 (1110)	II	57.08 (1200)	I	61.08 (1320)	II	60.24 (1350)	I
Less attention needed for trees	53.92 (1050)	III	52.84 (1050)	III	55.67 (1110)	V	49.69 (930)	V	49.44 (900)	VI
Less risk	52.65 (930)	IV	48.59 (870)	V	51.93 (930)	III	55.11 (1125)	III	52.83 (1020)	V
Less inputs	50.28 (840)	V	50.63 (900)	IV	52.39 (1020)	IV	52.64 (1020)	IV	54.66 (1110)	IV
Climate vagaries	48.31 (720)	VI	46.55 (780)	VI	48.68 (840)	VI	45.21 (810)	VI	58.63 (1290)	II

* Value within brackets are frequency (n = 1500)

Table-4. Level of domestication and extent of adoption of ToF in Tamil Nadu

Reasons	North Eastern zone		North western zone		Western zone		Cauvery delta zone		Southern zone	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Knowledge on tree cultivation	315	21	300	20	270	18	495	33	255	17
Quality planting material	195	13	165	11	195	13	315	21	138	09
Site selection	450	30	420	28	510	34	570	38	360	24
Proper soil selection	420	28	405	27	450	30	675	45	555	37
Type of planting material	1050	70	1005	67	1095	73	1125	75	840	56
Time of planting	855	57	825	55	900	60	870	58	660	44
Proper spacing	630	42	615	41	735	49	795	53	600	40
Digging of pits in appropriate sizes	1200	80	1170	78	1185	79	1125	75	915	61
Soil mixture	270	18	240	16	225	15	255	17	165	11
Soil working	90	06	75	05	120	08	138	09	90	06
Intercropping	855	57	810	54	930	62	1050	70	765	51
Weeding	675	45	645	43	720	48	825	55	855	57
Mulching	45	03	45	03	75	05	45	03	30	02

Irrigation	150	10	120	08	240	16	375	25	210	14
Application fertilizer	255	17	240	16	225	15	435	29	330	22
Plant protection measures	75	05	60	04	105	07	150	10	120	08

Table-5. Constraints faced by farmers in adoption of ToF in Tamil Nadu

Constraints	Frequency	Percentage
Labour		
Non availability of agricultural labours	7425*	82.50
Higher wages	7575	84.17
Inputs		
Quality planting material	7088	78.75
Cost of inputs like fertilizers	4867	54.08
Cost for plant protection measures	2813	31.25
Technology		
Non availability of silvicultural techniques	7200	80.00
Poor extension strategy	7875	87.50
Marketing		
Non availability of market intelligence	8062	89.58
Monopoly in price fixation	6563	72.92
Price fluctuation in ToF products	7350	81.67
Loan/credit/insurance facilities		
Non availability of loan for ToF activities	8625	95.83
Non availability of tree insurance or less information	8550	95.00
Others		
Linkage with other tree growers association	6600	73.33
Linkages with State Forest Departments, Wood based industries, research institutions, etc.	7050	78.33
ToF products sale through federations/associations	7650	85.00

*Frequency (n = 9000 farmers

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Exploring *VaKaranga* cosmological ethics of *kubata makuku* as a panacea for conflict management and resolution in Post-colonial Zimbabwe

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Abstract— *The political landscape of Zimbabwe shows that the country is battling to contain feuding conflicts in the society. It has become so obvious that any election in Zimbabwe is a contested terrain due to conflicts associated with the electoral process. Moreover, unsolved past conflicts continues to hinder the country's socio economic stability. It is clear from the state of affair that the Church and the State have failed to resolve conflicts in Zimbabwe. The church continues to preach from its pulpit unconditional forgiveness while state continues to sweep critical issues under the carpet. It is within this context that a tap into how the VaKaranga people resolve their conflicts through the ethical theory of kubata makuku can be a panacea in conflict resolutions. Moreover, the failure by the church to take sides with the oppressed during the struggle for justice in post-colonial Zimbabwe always present a challenge to the relevance of the church.*

Keywords— ***Kubata makuku, conflict, reconciliation, forgiveness, violence.***

I. INTRODUCTION

Conflict is inevitable in any society where people interact. Zimbabwe like any other country has its own share of conflicts which impacts negatively on its socio economic and political trajectory. Conflicts exist in many forms and this article traces post-colonial conflicts such as *Gukurahundi*, *Murambatsvina* and pre and post-election violence in post-colonial Zimbabwe. Efforts to resolve conflicts have been utilised by the church and the organ of Peace and Reconciliation Commission without much success. The church`s teaching of unconditional forgiveness will be put under heavy scrutiny in this article. The results of the research will help the church and the nation to rethink its approach to conflict resolution. *Kubata makuku* concept of resolving conflicts among the *VaKaranga* people will be utilised as the criterion of conflict resolution.

II. METHODOLOGY

The article will utilise the Praxis cycle or pastoral cycle. Praxis cycle refers to the on-going dance between theory and practice or reflective practice action and activist reflection. It is reflection aimed at liberatory actions. Praxis suggests the bringing together of action and reflection, transformation and understanding. This new marriage of action and reflection depends on accepting human life as fundamentally practical (Chopp 1986:37). It is within the realm of social analysis. One of the most powerful tools for change is called social analysis. Social analysis will help us to see why we have problems. It also helps us to work together in tackling these problems. The methodology will utilize a community-based praxis-approach (De Beer 2014) as developed in the pastoral cycle (Holland & Henriot 1983), as an expression of participatory action research.

The pastoral circle as proposed by Holland and Henriot (1983) involves five movements of immersion, social analysis, theological reflection, pastoral planning and spirituality.

2.1 Immersion

This involves the description of the conflicts which Zimbabwe is facing which requires a solution or to be resolved. Zimbabwe is experiencing a lot of unresolved conflicts which some predates the colonial era, colonial era and post-colonial era. It seems all efforts exhibited by the church and government fails to bring peace and reconciliation in a conflict ravaged society.

2.2 Analysis

The church has continued to teach unconditional forgiveness which has become an oppressive tool for the victims of injustice. The perpetrators of injustice continue to busk in the protection of the church's missionary theology of forgiveness. Most church programmes indicate that the issue of forgiveness is central to church but how forgiveness is interpreted leaves a lot to be desired. The missionary was convinced that the aspects of native life had to be wiped out and replaced by the Christian gospel (Samkange 1978:4).

On the other hand, the government continue to sweep under the carpet the negative impacts of conflict in the name of Peace and Reconciliation Commission. Every election in Zimbabwe is potentially a conflict year and sometimes with deadly effects of life losses.

2.3 Reflection

From the documentary evidence of the conflicts in Zimbabwe it is clear that the poor and the marginalised suffer most in times of conflicts and are the biggest losers. The voices from the people on the margins are very critical in coming up with the solution to the conflict. Centrally for the *VaKaranga* people is the dare which is a council used to resolve conflicts and bring transformation. How does the church interpret the scriptures in light of forgiveness and conflict management?

2.4 Planning for action

The issue of conflicts in Zimbabwe calls for deeper reflection of the meaning of forgiveness. A lot has been said about issues of reconciliation in Zimbabwe by churches and the Peace and Reconciliation Commission with very little success. The method of dialogue and conflict resolution continues to fall in the line of part politics and church teachings thereby discrediting or undermining the efforts of social structures in the society. It is in this context that the *kubata makuku* concept can be the ideal plan of action to bring lasting solution to conflicts in Zimbabwe and other countries.

The church must gear itself to address issues of conflict in a very practical way by making a deliberate effort to interpret the Biblical texts on forgiveness in the manner which takes care of the feelings, emotions and expectations of the victims.

2.5 Spirituality of liberation

The church and the State must explore African philosophy to solve conflict. Vellem (2014) asserts that African religiosity is the site of African liberation spirituality. It offers the methodological sources for the search of this spirituality of liberation. African religiosity is an important assert for a life-giving spirituality amidst the secularised eschatology of the global market. A conflict resolution strategy guided by African philosophy of Ubuntu which emphasises human dignity, sanctity of human life and egalitarian communities must be developed by states to resolve conflicts.

A new imagination that would unlock the power of African ways of resolving conflicts such as *kubata makuku* should be explored. If we long for peace in our communities, it is therefore high time that we must explore African ways of resolving conflicts. It is the responsibility of the church to reconstruct the spirituality of the people which have been violated by colonialism and missionary theology.

III. THE VAKARANGA PEOPLE

Nelson (1983:28) provides the history of the coming of the Shona people to Zimbabwe where the *VaKaranga* people belong. They came during a wave of Bantu-speaking migration originating in the Shaba region of modern Zaire which broke up in the tenth and eleventh century. This is associated with the coming of the Shona people to Zimbabwe. It was not until the nineteenth century when the name Shona was applied to cover several dialect clusters into which the Shona speaking people had traditionally been divided. These clusters had well-defined territorial bases and these include the *Kalanga, Karanga, Zezuru, Korekore, Manyika* and *Ndau (Nelson 1983:45).*

The centre of the royal clan's influence was at Great Zimbabwe, the ruins which lie near present day city of Masvingo. The ruins remain an impressive monument to the technical capabilities of an indigenous African Culture. Although by far the most spectacular of them, Great Zimbabwe is but one of the hundred and fifty *Madzimbabwes.* It housed a large population, the royal court, markets, warehouses and religious shrines (Nelson 1983:45).

Asante and Mazama (2009:616) asserts that the *VaKaranga* religion is monotheistic in nature, and they have a firm belief in the one God called *Musikavanhu (Creator) or Mwari* which has roots in the Bantu *Mu-ari* which literally means that which is self-existent. The same *Musikavanhu* can also be expressed as *Nyadenga* which means one who owns the skies or heavens and *Musiki* meaning one who creates or the Creator.

IV. CONFLICT ANALYSIS

Mudamburi (2019:92) asserts that conflict is disagreement between two or more people. It is difficult to avoid conflict in life. There are different sources and effects of conflict. Whenever there is conflict, people should learn to manage conflict peacefully. Conflict refers to some form of friction, disagreements or discord arising between individuals or within group when the beliefs or actions of one or more members of the group are either resisted or unacceptable to one or more members of the group (Tschannen-Moram 2001). Jeong (2010:3) asserts that conflict is manifested through adversarial social action, involving two or more actors with the expression of difference often accompanied by intense hostilities. Most significantly, protracted conflict arises from failure to manage antagonistic relationships.

There are several ways of dealing with conflicts and in this article I discuss the Thomas-Kilmann model which emphasizes on accommodating, avoiding, compromising, competing and collaboration. I will briefly discuss these ways in order to dissect through my argument.

4.1 Accommodating

This style of conflict resolution is about simply putting the other party`s needs before one's own needs. In this style one allow the other party win and get away with it. Accommodation is for situations where one does not care much on the outcome of the issue as the other person, if prolonging the conflict is not worth the time, or if one thinks he/she might be wrong (Thomas and Kilmann 2007). This option is about keeping the peace, not putting in more effort than the issue is worth, and knowing when to pick battles.

While it might seem somewhat weak, accommodation can be the absolute best choice to resolve a small conflict and move on with more important issues. This style is highly cooperative on the part of the resolver but can lead to resentment.

4.2 Avoiding

Avoiding as a style of resolving conflict aims to reduce conflict by ignoring it, removing the conflicted parties, or evading it in some manner. Team members in conflict can be removed from the project they are in conflict over, deadliness are pushed, or people are even reassigned to other departments. This can be an effective conflict resolution style if there is a chance that a cool-down period would be helpful or if you need more time to consider your stance on the conflict itself (Thomas and Kilmann 2007). Avoidance should not be a substitute for proper resolution, however; pushing back conflict indefinitely can and will lead to more (and bigger) conflicts down the line.

4.3 Compromising

Compromising seeks to find the middle ground by asking both parties to concede some aspects of their desires so that a solution can be agreed upon. This style is sometimes known as lose-lose, in that both parties will have to give up a few things in order to agree on the larger issue. This is used when a solution simply needs to happen, rather than be perfect. Compromise can lead to resentment, especially if overused as a conflict resolution tactic, as such it must be used sparingly (Thomas and Kilmann 2007).

4.4 Competing

This seems to be a stubborn position as it rejects compromise and involves not giving in to others viewpoints or wants. One party stands firm in what they think is the correct handling of a situation, and does not back down until they get their way. This can be in situations where morals dictate that a specific course of action is taken, when there is no time to try and find a different solution or when there is an unpopular decision to be made (Thomas and Kilmann 2007). The advantage of this style is that it can resolve disputes quickly, but there is a high chance of morale and productivity being lessened.

4.5 Collaboration

Collaboration style of resolving conflict produces the best long-term results, while at the same time it is often the most difficult and time-consuming to reach. The waring party's needs and wants are considered and eventually a win-win solution is found. In this scenario everyone is satisfied by the outcome of the dialogue. This often involves all parties sitting down together, talking through the conflict and negotiating a solution together. This is used when it is vital to preserve the relationship between all parties or when the solution itself will have a significant impact (Thomas and Kilmann 2007).

After looking at these ways of conflict resolution I find it hard to believe that these ways help to resolve conflict. As a *Mukaranga* man who grew up in a society where I have seen conflicts with potential to degenerate into brutal wars solved through *kubata makuku* propose this method as a framework of conflict resolution and management.

V. KUBATA MAKUKU

For the *VaKaranga,* true forgiveness and reconciliation comes after *Kubata makuku. Kubata makuku* when translated literally means catching hens (Muzenda 2019). This is a concept which is used in most *VaKaranga* villages to settle differences. If a person has wronged another person a council (dare) is called to look into the issue and anyone found guilty must *bata makuku*. So, for the *VaKaranga* forgiveness is not an abstract philosophy but a practical and comprehensive process.

The concept of *Kubata makuku* is universal in dealing with issues of forgiveness and reconciliation in most *VaKaranga* communities (Muzenda 2019). The concept may sometimes be used even when the offence is so huge that the person is requested to pay a goat or a cow, but the goal is to bring reconciliation. Once someone has done the process, the honour is on the community to make sure that there is true reconciliation.

Amnesty International`s work on racism and justice (2000:40) assets that there can be no lasting peace or reconciliation without justice. Those responsible for genocide and other human rights abuses must be brought to account. In many other parts of Africa where States combine an enormous variety of ethnic groups, conflicts and human rights violation frequently have an ethic context. History may explain particular situations of ethnic domination, but all too often governments that should be striving to implement equal rights for all their citizens and prevent discrimination are manipulating ethnic divisions for short-term political ends and thereby contributing to ethnic conflict. They are also failing to combat racial discrimination of justice. This creates a group of second class citizens.

Wiredu (1996:181-182) asserts that "what is central to the process of reconciliation is the re-appraisal of the importance and significance of the initial bones of contention". It therefore, means instead of trying to avoid the causes of the conflict, through reconciliation, there is need for all the parties to the conflict to present their demands and that a proposed settlement should take into account the existence of these various demands. This is more like collaboration style of conflict resolution.

Schreiter (1998:64) asks the question: where does forgiveness come in the reconciliation process? The common sense answer is first comes repentance on the part of the wrongdoer, then the victim forgives and then there is reconciliation. There must be some act of apology or acknowledgement or repentance by the wrongdoer. Guilt must be admitted and then the victim can be summoned up for forgiveness. Unfortunately, this rarely happens in the social arena. The wrongdoers are still too powerful to be coerced to submit to such process. In other cases, an amnesty is extended that protects the wrongdoer from being legally accused of wrongdoing and punished. Social reconciliation must follow fashion common sense process of repentance, forgiveness and reconciliation.

Reconciliation is a concept that has been appealed to by many countries that have tried to move from a situation of civil war to peace. There is no exception with Zimbabwe under Robert Mugabe, the man who led the country into independence appealing to the concept of reconciliation when he tried to set up a new nation and to rebuild the newly independent Zimbabwe. Kaulemu (2008:7) argue that, this reconciliation was called for even before the basic injustices that had caused civil war in the first place were fully addressed. If the concept of kubata makuku was applied soon after Independence I want to argue strongly that *Third Chimurenga* could have been avoided in Zimbabwe. *Third Chimurenga* was a war which Zimbabweans fought to take back their land from White commercial farmers around the year 2000.

Gutierrez (1983:183) averred that the building of a different society and of a new human person will only be authentic if it is undertaken by the oppressed themselves. Hence, the point of departure for this undertaking must be the values of these persons. *Kubata makuku* seeks to integrate human value and gender sensitive. For it is from within the people that the prevailing social order is being so radically questioned. It is from within the people that the culture of oppression is on its way to being abolished. Indeed, this is the only way in which a genuine social and cultural revolution can be carried out.

Cone (1978:219) confirms that it would be the height of stupidity for victims of oppression to expect the oppressor to devise means of liberation for the oppressed. The church and the government on issues of conflict resolution have become the oppressors of victims. *Kubata makuku* is the only way for true reconciliation in which all the aggrieved parties are supposed to agree on the way forward.

Zimbabwe is currently embroiled in quite a number of unresolved conflicts. For instance, the pre-independence tribal tensions between the Shona and Ndebele, aggravated by the *Gukurahundi* killings in 1983, have not been resolved. *Gukurahundi* saw the deployment of the Fifth Brigade to Matebeleland and parts of Midlands which resulted in between 10000 to 30000 Matebele slain by Mugabe`s private Army. *Gukurahundi* ordinarily refers to the wind which blows away the chaff before the rains (Hill 2003:77). It is precisely this meaning ascribed to the operation *Gukurahundi* that is seen by some to mean the wiping out of ZAPU and the *Ndebele* population`s contribution to the liberation history.

The issues of *Gukurahundi* as an example cannot be resolved through a political statement but through serious engagement. A dare must be called of reputable people and come up with a lasting solution where the perpetrators of this violence must bata makuku. One of the most important feature of dare among the *VaKaranga* people is that those of little wisdom cannot be part of the dare. They are usually given other chores and the most common one is *kunovhiya mbudzi* (skinning the goat). When given the task of *kunovhiya mbudzi* it means you lack wisdom and cannot contribute any meaningful insights into the issue before the

dare. A theology of *Kubata makuku* can be a panacea to several conflicts in Zimbabwe and around the world.

Attempts have been made at the highest political level to address the animosity that exists between tribes, but with little or no consideration given to grassroots projects focused on reconciling differences and promoting cooperation and dialogue. The highly centralised government and one-party system-constituted since independence in 1980-has been accused marginalising minority ethnic groups in Zimbabwe.

Gukurahundi is not a closed chapter unless and until a proper audit of the life lost and a serious engagement with those who lost their loved ones. For the government of Zimbabwe to simply say 'it was a moment of madness' is not enough to bring peace and reconciliation. The government must bata makuku in order to bring closure to the issue.

There was also violence during operation Murambatsvina where authorities bulldozed, razed and destroyed what was labelled 'illegal structures' that included but not limited to houses with approved plans in residential areas and well established markets (Nyere 2014). The first official launch of Operation Murambatsvina was 19 may 2005. During the launch Ms Makwavarara Chairperson of the Harare Commission emphasized that the program was to enforce the Regional Town and Country Planning Act to stop illegal activities which included among others; vending, trading in foreign currency and illegal dwellings.

Harare residents were ordered to destroy the illegal structures which they had erected themselves before 20 June 2005. However, on 25 May 2005 in complete disregard of the official deadline, a huge military style operation started in Harare spreading to many cities and towns. Many houses, tuck shops, market stalls, flea markets, vegetable markets, hair salons and many residential structures were destroyed in a well-orchestrated paten of repression.

Many people were rendered homeless including those who had local council papers as rightful owners of the properties. The issue of *Murambatsvina* was just swept under the carpet yet the government of Zimbabwe through its local authorities was supposed to bata makuku. The issue of demolition of houses has become a norm in Zimbabwe since every year we continue to witness such ugly scenes. The poor people continue to lose their hard earned money to land barons. *Kubata makuku* could be used as a solution to conflict resolution. I may argue that the issue of Murambatsvina is of the major reasons why ZANU PF is failing to gunner majority votes in towns and cities.

Over the years there have been election-related complaints from political parties and private individuals but these have been ignored. Many crimes have also been committed during election times. Cases of abduction, unlawful arrests, murder, rape, arson, and disappearances have been reported but without state investigation or legal redress. Victims have largely remained uncompensated. The famous Itai Dzamara issue is the case in point who just disappeared without trace and many others.

The 2008 election re-run saw more than 200 MDC activists murdered in State led election violence. While on another note 5000 MDC supporters were tortured and displaced from their homes. Furthermore, the events of the 2008 presidential election still linger in the collective conscious of the electorate because of the violence and destructive nature of election. The period leading to the Presidential run-off was characterized by widespread state violence against and repression of suspected opposition supporters especially in rural areas. Even after the election violence continued and on 2 July 2008 some 200 Zimbabweans sought refuge at the American Embassy in Harare (Kanete, 2019:4). Sachikonye (2011:21) assets that in Zimbabwe there is institutionalized violence during and after election.

In the post-independence era the worst example of politically motivated violence was the massive massacre of thousands of thousands of civilians in Matabeleland in an orgy of killing known as *Gukurahundi*. The main purpose of these deliberate killings, rapes, torture and destruction of property was the elimination of ZAPU`s popular following as a way to force the party leadership to submission. What is striking though is the savagery of the onslaught by the North Korean-trained and Shona recruited Fifth Brigade, the CIO, some other units and the ZANU PF Youth League. This left thousands of people dead and many more maimed and marked for the rest of their lives. Most families were and are still affected one way or the other.

These are just some of the conflicts which Zimbabwe is experiencing and the theology of *kubata makuku* can be utilised to bring restoration. To pretend as if nothing has happened is digging a deep well for the nation. Forgiveness for the VaKaranga is conditional. One has to meet certain conditions for him/her to be forgiven. The Africans were Christians in so far as all was well with them, but as soon as they encountered problems, they reverted to traditional forms of tackling those problems (Banana 1991:65). This assertion by Banana is wake up call to Africans that their traditional ways of dealing with conflict is very effective.

Mugambi (1997:7) argues that, if Africa is to face the future realistically, African cultural dimensions of life

must be emphasized much more than in the past. There will be no future for the majority of our people without serious appreciation of God's religious cultural gifts to Africa.

Although European missionaries and colonialists brought the Bible with them to Africa, it can be argued that the encounter with Christianity and the encounter with the Bible should be examined separately. The argument is that a careful exploration of the ways in which Africans appropriated the Bible will identify a range of interpretative strategies that enabled converts and colonized Africans to "read" the Bible in an empowering and affirmative manner (Mugambi 1997:236). Unconditional forgiveness is not VaKaranga philosophy of life.

African Christian theology in the twenty-first century," says Mugambi," will be characterized by the themes of social transformation and reconstruction. The shift from liberation to social transformation and reconstruction involves discerning alternative social structures, symbols, rituals, myths and interpretations of Africa's reality by Africans themselves, irrespective of what others have to say about the continent and its peoples. The resources for this re-interpretation are multi-disciplinary analyses involving social scientists, creative writers and artists, biological and physical scientists. Theology, as the systematic articulation of human response to revelation in particular situations and contexts, will be most effective if, and only if, the social and physical reality of the peoples is accurately and comprehensively understood and re-interpreted (Waruta 1995:110).

Tutu pleads for us to remember that in the act of forgiveness we are declaring our faith in the future of a relationship and in the capacity of the wrongdoer to make a new beginning on a course that will be different from the one that caused us the wrong. Unwillingness to forgive keeps us in prison and we should offer forgiveness even before it is asked for. This is where I differ with Tutu especially that the victim must offer forgiveness before it is asked for. This notion has helped the perpetrators of injustice to continue to oppress their victims for they know that forgiveness is on a silver platter. This justifies the theology of kubata makuku where the *VaKaranga* people will say we can only forgive you if you *bata makuku*.

For a nation of Zimbabwe to simply say *Gukurahundi* was a moment of madness is not enough to deal with the trauma encountered during the genocide. To say let bygones be bygones is a travesty of justice. It is however true that communal forgiveness cannot unite a disjointed community until injustices that continue to create the powerful and the powerless are dealt with. There can be no communal forgiveness without a profound realignment of power which operates in a society. Communal forgiveness can only occur within a relationship based on justice and equality.

Banana (1993) argues that Christianity was the perfect instrument for the subjugation of the people. The white missionary and the white church used the faith and Scriptures to justify oppression. Christianity continued to believe in and practicing a theology that kept the Bible captive to an enslaving hermeneutic. This implies that Christianity has to a larger extent influenced how people react to issues of forgiveness and conflict resolution. Is it not time that African Christianity utilises more of African concepts to resolve conflict such as *kubata makuku*.

In its originality, *kubata makuku* does not discriminate against women. If a husband has wronged his wife, he must *bata makuku*. There is no male dominance in the concept of *Kubata makuku*. It is therefore, quintessential to note that since time immemorial the VaKaranga people have been accommodating women and gender sensitive. Zimbabwe need to make a clean break with its history of violence and resolutely walk the road of peace by creating a constitutional state guaranteeing participatory and prioritizing respect of the rule of law (Mkaronda et al, 2003:96).

VI. CONCLUSION

The purpose of this article was to explore the *VaKaranga* cosmological ethics of *kubata makaku* as a solution to conflict management. *Kubata makuku* can be utilised as a model for resolving conflict in Zimbabwe and in Africa. The church must stop the preaching of unconditional forgiveness and become more realistic and practical in as far as conflict resolution is concerned. Without kubata makuku perpetrators of violence will remain on top of the situation. Zimbabwe need to take the ethics of *kubata makuku* seriously for it to deal with conflict situations in the society. *Kubata makuku* places responsibility of actions to those who perpetrate discomfort in the society. *Kubata makuku* for *VaKaranga* people promotes *unhu/Ubuntu*.

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Priming Applications with Mosquito (Diptera: Culicidae) Larva Rearing Water in White Cabbage Seeds (*Brassica oleracea* L. var. *capitata* F. *alba* cv. Yalova 1)

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Abstract— *The starting material with good quality is a portent of a satisfactory and good harvest in vegetables grown from seedlings such as cabbage, a good beginning makes a good ending. Seed pre-applications promote uniform and rapid germination/emergence, leading to strong seedling formation. In this study, bio-based larval rearing water was used as an organic priming agent and its effect was compared with the effects of hydro priming. As a result of the study, the effects of both priming applications on germination and emergence were superior to the untreated control in terms of mean time and vigor, but there were no differences according to germination and emergence percentages. According to mean time of germination organic primed seeds germinated in the shortest time with 2.45 days compared to hydro primed seeds (2.77 days) and control (3.48 days). Likewise, this, organic primed seeds were emergence in 6.80 days, hydro primed seeds were emergence in 7.19 days and control seeds were emergence in 7.39 days. Vigor index of germination was 19.09 in organic priming, but it was 17.48 in hydro priming and 14.56 in control. On the other hand, vigor index of emergence was 6.39 in organic priming, 5.67 in control and, 5.28 in hydro priming applications. In addition, organic priming came to the fore among organic priming and hydro priming. It is thought that this positive effect may be due to the nitrogen and organic carbon content of larval rearing water.*

Keywords— ***Cabbage, Hydro priming, Larval rearing water, Organic priming.***

I. INTRODUCTION

Main purpose of priming applications is stimulating the biochemical activities via increasing water uptake of seeds for uniform and faster germination and emergence [1]. For these purposes, water, some salts, or various chemicals can be use. In addition to these, the use of bio-based/organic materials in priming applications have been investigated in recent years[2-5]. In this studies, organic priming of seeds defined as the safe and practical approach and which organics are safe, ecofriendly, economical, and easily available. Also, these applications provide especially hardiness to various unfavorable environment conditions such as extreme temperature and moisture. It induces faster germination in seeds and higher seedling vigor leading to higher crop productivity. These effects presented with various research. For example; in cluster bean the main benefits of organic seed treatments include increased phosphate levels, nitrogen fixation and root development [6]. In *Capsicum* species organic priming applications promote larger seedlings with greater fresh and dry weight for all species and suggested that priming may be used to enhance pepper seedling performance [7]. In watermelon organic priming provided faster and earlier seedling development [8].

Vigor is a major seed trait, which designates the potential of uniform emergence and seedling development even under undesirable growing conditions. Uniform seedling establishment is mandatory in all vegetable crops and can be achieved by improving seed quality [9]. There is some approach to enhance of the seed quality before sowing,

even if seed quality improved by breeding, for various reasons such as unfavorable storage conditions, seed age, insufficient labor etc. In addition of these priming application provide a recovery chance for aged or damaged seeds [2]. There are different seed vigor improve techniques, priming is one of those. Heterogeneous germination and seedling emergence have direct influence on field performance of the plants either of the transplanted vegetable crops[9].

Cabbage is widely growth nearly all countries, mostly Asian and Northern Europe. It can be use as fresh or cooked, as pickled, as medicine or feed [10]. Cabbage contains plenty of various minerals, water and fiber, as well as is very rich in vitamins K and C [11]. In 2020, cabbages and other brassicas was produced 71 million tonnes in the world at 2.4 million ha. Turkey is the 11th cabbage producer in the producer countries according to production quantity (852.000 tonnes).

Seedlings are widely used in cabbage culture. Irregular seed quality leads to extended emergence time and non-uniformed seedlings of cabbage. That variable sized seedlings, when transplanted, produce variable sized cabbage heads which cannot be harvested and marketed at one time [9]. Thornton and Powell [12] reported improvements in seed quality of Brassica oleracea via hydro priming. Hydro priming, imbibition of seeds before sowing, is an easy and inexpensive method to improve seed emergence and seedling uniformity [13].

Gravit female of *Culex pipiens* Linnaeus, 1758 (Diptera: Culicidae) (northern house mosquito) lays eggs in a raft in a boat-shaped structure, consisting of several hundred eggs. As the breeding site, this species prefers natural or artificial containers that accommodate up to several liters of water. The embryonic development takes about 2–7 days or more depending on the temperature, and immediately after, the larval emergence occurs. The aquatic process, consisting of four larval and one pupal stages, is usually completed within one week or more, depending on temperature and other environmental drivers, such as food level (organic debris, bacteria, protozoans, fungi and other microorganisms) and the density of larvae in the water [14]. To date, a limited number of studies have been conducted to determine the effects of mosquito larvae on the rearing water, particularly touching on the subject from a microbiological point of view. Depending on the species and environmental conditions, these studies revealed that presence of mosquito larvae can alter the microorganismal composition of water and can enhance, reduce, or have little effect on the total bacterial abundance [15-18]. In most of the relevant studies, a few mosquito species have been focused, such as *Aedes triseriatus* [15, 17], *Culex nigripalpus* [19], and *Culex restuans* [18]. The effects of larvae on the rearing water have been mostly explained through the trophic cascade [18, 19]. However, it has also been emphasized that mosquito larvae can play an important role in the structuring of microbial food sources, and release of some nitrogenous wastes by the larvae may be one of the crucial effects in this phenomenon [18]. As far as we know, there is no detailed data on the effects of *C. pipiens* larvae on the rearing water, the specific molecules that are possibly excreted/secreted by mosquito larvae or microorganisms exposed to the larvae, and the potential effects of these possible molecules on any animals or plants.

Objectives of the study reported here were (1) the evaluation of bio-based rearing water of mosquito species *C. pipiens* effects on germination and emergence of cabbage seeds and (2) to compare its' effect with hydro priming.

II. MATERIAL AND METHODS

In this study, commercial standard variety "Yalova 1" white head cabbage seeds treated with Thiram used as plant material. With take into considerations of several previous investigations [13, 20, 21], seeds were subjected to two different priming solutions [hydro priming (PW) and larval rearing water (LRW)] and three different soaking durations [one day soaking (1DS), three days soaking (3DS) and soaking until 1% of seeds radicle appearing (approximately 1.5 days, 1G)] and in addition of those non-pre-applied seeds used as control (C). After these applications, all seeds were dried to initial seed weight except C groups seeds. All seeds threated with Mancozeb 64% (Syngenta, Ridomil Gold MZ 68WG) to protection against fungal contaminations before sowing. Experimental design was randomized complete plots with three replications.

To obtain the rearing water of *C. pipiens* larvae, seven containers made of hard plastic and each containing two liters of water were used. In each container, 200 first instar larvae were placed and fed with fry food, considering the relevant instructions and warnings [14]. The emerged adult mosquitoes were collected daily. Eventually, an average of 197.2 (range 194-200) adult mosquitoes, 103.1 (range: 96-110) male and 94.1 (range: 90-104) female, emerged from each container. All the larval rearing water from the seven containers were mixed in a stock container, and all the trials were carried out using this mix.

The larval rearing water evaluated for its some features. According to the total organic carbon analysis, it was included 18 mgL^{-1} total organic carbon (38 mgL^{-1} total carbon) and 25 mgL^{-1} total nitrogen. According to the

physicochemical measurements it has 0.65 mS cm^{-1} EC and 8.40 pH values.

Plant Growth Chamber (ALC 800) was used for the conduct of the study settled at 24±1˚ C, 65±5% RH and, darkness conditions. Germination and emergence parameters were evaluated in the study. For germination tests 50 seeds were planted into each petri dishes (9 cm Ø, plexiglass) and, for emergence tests 50 seeds were sown at a depth approximately 0.5 cm in growing medium filled trays (8x25x50 cm, PE) per replicate. The commercial peat recommended to produce vegetable seedlings was used as a growing medium (Klassmann Potground-H, Doktor Tarsa Inc., Antalya, Turkey). It had pH of 6.0, EC-value of 0.40 dS m^{-1}, Added amount of fertilizer (NPK fertilizer 14:10:18): 1.5 kg m^{-3}.

The counts were done daily, and it was accepted as germinated when approximately 2 mm radicle appeared and as emergenced when the cotyledons were parallel to medium surface. Observations conducted until there was not germination and emergence in three consecutive days.

Percentage of germination (GP) and emergence (EP) was calculated by proportion and arcsine square root transformation values used for statistical analyses, but real values of germination/emergence percentages presented in Tables. Mean germination time (MT_G) and mean emergence time (MT_E) were calculated according to Formula 1. Vigor indexes of germination (VI_G) and emergence (VI_E) were calculated according to Mereddy, Wu [22] (Formula 2).

$$MT = \frac{\sum n.t}{\sum n} \qquad \text{(Formula 1)}$$

n = number of newly emergenced seedling/germinated seed at a time t, t = days from sowing/planting, and Σ n = total emergenced seedling/germinated seed.

$$VI = \left(\frac{G1}{D1}\right) + \left(\frac{G2}{D2}\right) + \cdots + \left(\frac{GL}{DL}\right) \qquad \text{(Formula 2)}$$

G1 = number of emerged/germinated seeds (first count), D1 = number of days to first count, GL = number of emerged/germinated seeds (last count), and DL = number of days to last count.

All data were subjected to analysis of variance (ANOVA) and mean value were compared with the LSD test. Statistical analyses are conducted in R statistical analysis software version 4.1.0. [23] and Agricolae library [24].

III. RESULTS AND DISCUSSION

According to ANOVA results in GP among durations, in MT_G application main effect, in VI_G both among durations and application main effect (Table 1).

In MT_E application main effect, and in VI_E application main effect were significant but EP was non-significant (NS) statistically. Differences among all the combinations (applications x durations) were statistically significant (Table 2).

Percentage of germination ranged between 60.00% and 88.00% and there were not significantly differences among combinations except PW 3DS. While combinations were statistically different there was no difference in application main effect (Table 1).

According to mean time of germination, applications main effect was statistically significant. LRW applications' seeds germinated in the shortest time with 2.45 days compared to PW (2.77 days) and control (3.48 days) applications. Combinations of applications and conditions were significantly different. When combinations of LRW and 1DS, 3DS, 1G and combination of PW and 1DS placed same group (a), PW and 3DS, 1G combinations placed same group (ab) and C placed group by itself (b).

Vigor index of germination (VI_G) is significantly different according to the combination of applications also application main effect. As GP and MT_G, combinations of LRW and application main effect of LRW showed best results compared to PW and Control applications (Table 1). Distribution of germination by days showed at Fig.1. According to the distribution of germination graph all of seeds of LRW 1DS, 3DS and 1G conditions nearly germinated at first seven days.

Table 1. Germination percentage (GP), mean time of germination (MT_G) and vigor index of germination (VI_G) seeds of primed with water (PW) and larval rearing water (LRW) one day (1DS), three days (3DS) and until the appearance 1% of seeds radicle (1G).

Applications	Conditions	GP (%)	MT_G	VI_G
PW	**1DS**	**86.67a**	**2.47a**	**20.53a**
	3DS	**60.00b**	**2.93ab**	**12.83b**
	1G	**83.33a**	**2.93ab**	**19.09a**
	Mean	**76.67**	**2.77AB**	**17.48AB**

LRW	**1DS**	**78.00a**		**2.41a**		**17.80ab**	
	3DS	**80.00a**		**2.54a**		**19.53a**	
	1G	**81.33a**		**2.42a**		**19.95a**	
	Mean		**79.78**		**2.45A**		**19.09A**
	Control	**88.00a**	**88.00**	**3.48b**	**3.48B**	**14.56ab**	**14.56B**
	LSD value	**8.344 (α:0.05)**		**0.556 (α:0.01)**	**0.777 (α:0.001)**	**5.330 (α:0.001)**	**3.595 (α:0.1)**

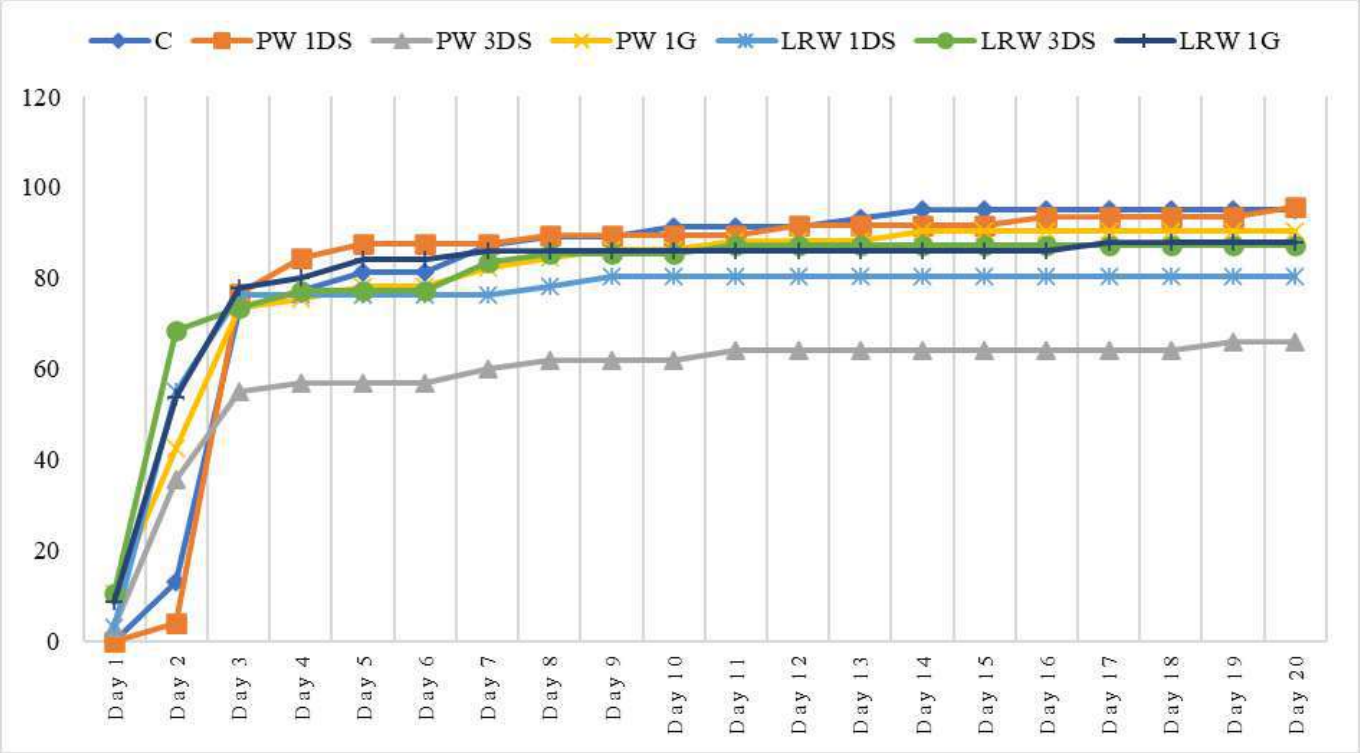

Fig.1. Distribution percentages of germination by days

Emergence parameters were showed a similar pattern to germination parameters. In all parameters combinations of LRW showed the best results. According to the EP LRW (1DS, 3DS and 1G) and C grouped together (a). One percent of seeds germinate in LRW showed the highest emergence rate (85.33%) and three days soaking of PW showed the lowest emergence rate (56.67%). Application main effect not statistically significant in EP. Main time of emergence was statistically different for conditions and application main effects. One day and three days soak of LRW showed the shortest mean time (6.69, 6.78 days) and control was showed the longest mean time (7.39 days).

According to application main effect of mean time of emergence PW (7.19 days) and LRW (6.80 days) were superior to control application (7.39 days). Vigor index of emergence showed comparable results with VI_G. Application main effect of VI_E was the most favorable in LRW when it compared to PW and Control (

Table 2). Distribution of emergence by days showed at Fig.2. The sixth day was the busiest day of the emergence trial, most of seeds were emergence at sixth day for all conditions.

Table 2. Emergence percentage (EP), mean time of emergence (MT_E) and vigor index of emergence (VI_E) seeds of primed with water (PW) and larval rearing water (LRW) one day (1DS), three days (3DS) and until the appearance 1% of seeds radicle (1G).

Applications	Conditions	EP (%)		MT_E (days)		VI_E	
PW	**1DS**	**82.67a**		**6.87ab**		**6.28a**	
	3DS	**56.67b**		**7.36cd**		**4.12b**	
	1G	**74.00a**		**7.32bcd**		**5.44a**	
	Mean		**71.11**		**7.19A**		**5.28B**
LRW	**1DS**	**84.67a**		**6.69a**		**6.69a**	
	3DS	**78.00a**		**6.78a**		**6.03a**	
	1G	**85.33a**		**6.93abc**		**6.46a**	
	Mean		**82.67**		**6.80A**		**6.39A**
	Control	**79.33a**	**79.33**	**7.39d**	**7.39B**	**5.67a**	**5.67AB**
	LSD value	**9.188 (α:0.05)**		**0.394 (α: 0.1)**	**0.488 (α:0.05)**	**1.085 (α:0.05)**	**1.119 (α:0.1)**

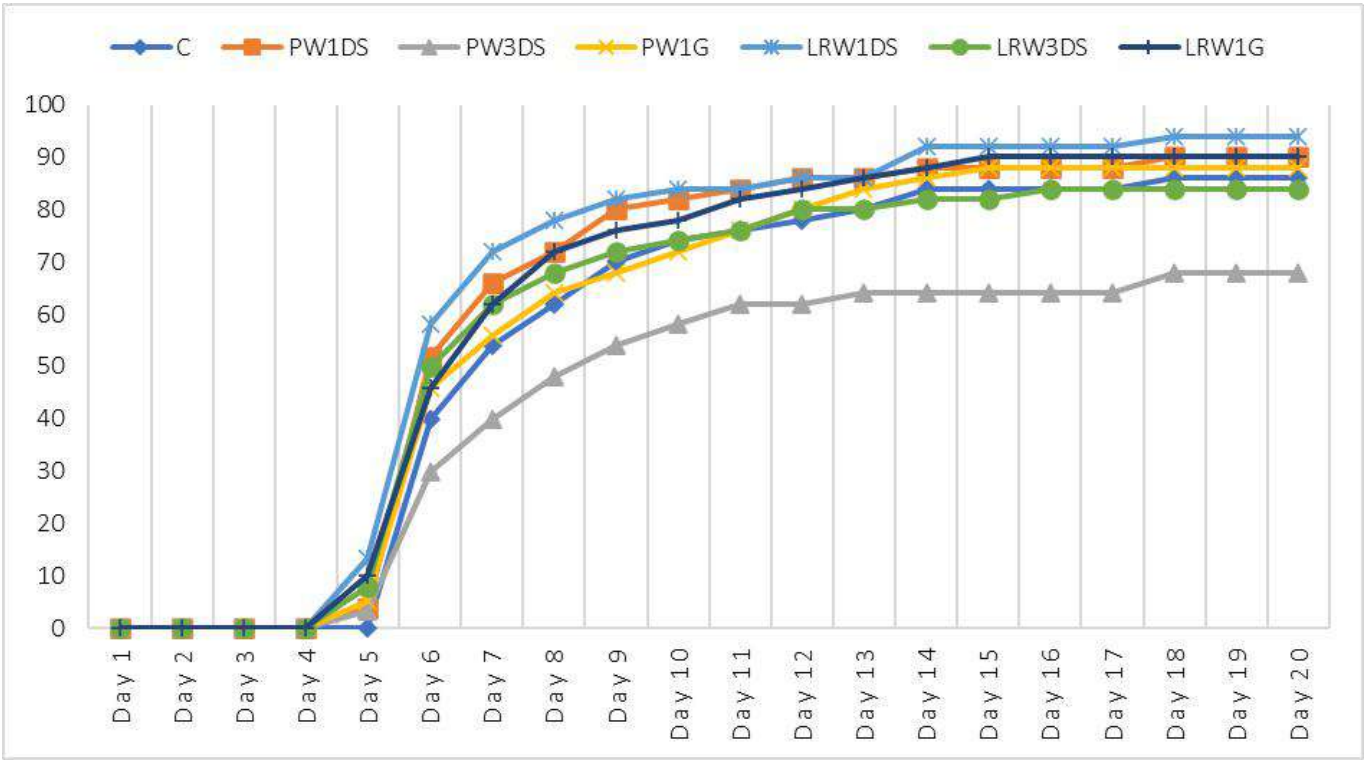

Fig.2. Distribution percentage of emergence by days

Among all combinations, PW 3DS has the lowest germination and emergence performance. The reason of this situation could be long priming time. In the seeds of 1G application, radicles were appeared in approximately 1.5 days. In PW 3DS application, seeds subjected to hydro priming longer time than other applications. The reason of that it could be seeds in PW 3DS application insufficient oxygen. On the other hand, it was not same effect seen in the LRW 3DS. It could be thought that the reason why it

was due to the positive effect of LRW on the germination and emergence performances (Figure 1 and 2).

Özkaynak, Yüksel [8] were use laurel, thyme and seaweed extracts and PEG_{6000} for comparing chemical and organic priming applications in watermelon seeds and showed that extracts efficient as PEG_{6000} in germination rates. Özkaynak, Orhan [25] were also use laurel, thyme, and seaweed extracts for organic priming in tomato and pepper seeds and suggest that while in pepper seeds seaweed and laurel extracts showed the highest germination rates, in tomato seaweed and thyme showed the best results. In this study, PW and LRW both showed higher performance compared to control, however LWR has the best performance in all parameters.

Takoliya, Patel [26] determined that green leafy vegetables seeds treated with seaweed extract as a bio-priming were showed higher vigor, germination percentage, seedling length and, seed stamina index than untreated seeds. Sivritepe and Sivritepe [21] and Sivritepe, Şentürk [20] were use seaweed extract in pepper seeds for organic priming applications and suggest that the seaweed extract applied seeds showed superior vigor compared to control group. In our study LRW has been same effect as bio-priming agent.

It were used different concentrations of cow urine in cluster bean for organic priming applications by Ambika and Balakrishnan [6]. Researchers suggest that the cow urine (2%) can be recommended as organic seed priming for increasing the vigor in cluster bean. It can be thought that the LRW used in our study showed similar effects depending on the organic carbon and nitrogen content.

IV. CONCLUSION

Seed priming is a very important, efficient, applicable and inexpensive method to increase the germination, emergence, the growth, as well as the productive capability of vegetable crops. There is no single method applicable to all species to initiate germination metabolism without radical protrusion. For the identification of species-specific methods water, inorganic salts, sugars, solid medium with water and nutrients, beneficial microbes, micronutrients, hormones, rhizobacteria, and organic sources are used as priming agents for seeds [2].

In this study both hydro priming and larval rearing water as organic primig used for improve seed germination and emergence properties in cabbage seeds. Both methods positively induced the mean time of germination/emergence and, the vigor index of germination compared to control group. However, there was no difference among the applications according to germination and emergence percentages. Comparing LRW and PW applications, it was seen that LRW gave superior results in MT_G, VI_G and VI_E.

Primed seeds can show in high germination and seedling emergence rates, vigorous early growth, early flowering, maturity and higher yields than unprimed seeds [26]. The results of the present study showed that seed priming with LRW improve the germination and emergence of cabbage seeds. Hence, priming with LRW could yield to uniform seedling production. In future studies, examining the performance of seedlings obtained from LRW-treated seeds will help to better understand the effects of this material.

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Automated Milk Quality Analyzer with Billing System

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Abstract— *Agriculture is an important part of India's economy, and the dairy sector provides to the country's profitability. As we all know, the global has grown at a faster rate, with people embracing a more affluent lifestyle to meet shifting expectations and needs. As a result, it is critical to reform the current farming and dairy management practices in India in different criteria, such as FAT, classifications of various milk characteristics, and so on. Another concern is that the process is done manually, which makes it susceptible to errors. As a result, it is necessary to reduce physical labour to improve results. The current system must be replaced with a new one that utilizes automated milk sample measuring technology. In our proposed system, we have developed a low-cost and reliable milk parameter detection and analysis system that uses an Arduino controller. On the other hand, the milk quality is checked, evaluated, and shown in a matter of seconds. As a result, the goal of implementing the suitable information technology stated in this project is to make information symmetric in the market, thereby minimizing problems of adverse selection and tedious work.*

Keywords— ***Milk Analyzer, Fat, Ammonia, Humidity, Billing System.***

I. INTRODUCTION

In India, milk production yields a larger return for both farmers and dairy farms. Milk and milk items are consumed by almost Eleven billion people across the world, with 70 per cent of children suffering from malnutrition each year. Adulteration is one of the major problems in India and also in some of the developing countries and in some advanced countries too. Many milk producers and sellers add adulterants such as urea and common salts are added to increase solid-not-fat (SNF), Ammonium sulphate is added to increase the lactometer reading by maintaining the density of diluted milk, Formalin, Salicylic acid act as preservatives and increase the shelf life of the milk.

Many scientific papers have been proposed on the detection of milk adulteration and adulterants present, the paper by Vasudha V Ayyannawar Et al. [1] proposes a system that allows you to justify the quality of milk. On the LCD, the exact FAT values are displayed, and these values are instantly communicated over the internet, where anyone can obtain the information. Farmers will be able to sell their milk at a reasonable price as a result of these accurate valuations. The writers Dr G Rajakumar Et al. [2] designed an IoT-based system in this research that provides faster and more reliable results. Microbial activity is measured using a gas sensor in our suggested method, a level sensor is used to identify the level of the milk, as high-quality milk should have no salinity. This technology measures milk collection factors such as weight, FAT, and CLR and provides quick results. The work by S Priya Et al. [3] is based on smart sensor technology, this project determines the parameters of milk. Here, we consider parameters like temperature and pH to determine the quality of the milk. The Temperature sensor is used to determine the hotness or coldness of milk. The pH sensor is used to determine the pH of the milk.

In this paper, we have proposed a system for the creation and deployment of a low-cost and reliable milk parameter detection and analysis system utilising an Arduino controller. The prototype is a basic milk analysing system using a phototransistor and a coupled LED as a module. The transmitter and receiver are separated by a modest distance inside the container sample setup. As a consequence, the findings are examined based on the

change in resistance produced by the fat content in milk. The gas sensor is used to detect microbial activity in milk, while the humidity sensor provides humidity information. Finally, the processed data is presented on an LCD panel and updated on the ThingSpeak cloud platform, which allows data to be accessed over the internet. A billing system is established, in which each user will have their own data set with data collected for the amount of milk generated.

The paper has four more chapters. Chapter 2 gives the details of the motivation behind the selection of the project. Chapter 3 includes the block diagram of the complete prototype, an Input section consisting of a setup of LED coupled with LDR, gas & humidity sensors, an Output section consisting of an LCD & ThingSpeak database and the Circuit diagram of the prototype. In chapter 4, the experimental results of the prototype with different types of milk analysed are shown in a tubular column and their respective outputs are displayed in LCD and uploaded to ThingSpeak. Chapter 5 provides the conclusion and future enhancement.

II. MOTIVATION

i. There are many new technologies included in the determination of adulterants in milk, but these technologies are still not affordable for small industries and farmers to evaluate milk quality and determine an exact price for milk based on that quality.

ii. Milk processing takes longer since it must first be evaluated for quality by measuring its FAT content, density, and quantity after being purchased from farmers. As this process is time-consuming hence farmers have to stay in line for an hour or more.

iii. The milk sample for testing is kept in plastic bottles and only assessed once the milk collection process is over, thus the sample will be checked after one or two hours. Some milk collection sites do not have the most up-to-date milk analysing equipment.

iv. Since all measurements are performed manually, there is a potential that cooperative staff members' handwritten calculations of quality and quantity contain inaccuracies.

III. PROTOTYPE DEVELOPMENT

To run a Milk Analyzer in real-time accurate hardware components and software components in addition to network connectivity. The milk analyser uses multiple sensors to test various parameters. These sensors include gas, humidity and temperature sensor & a module coupled with LED & LDR. These sensors provide various readings that will help analyse for better detection of milk parameters.

The sensors are connected to the microcontroller which is used for data acquisition and signal conditioning. The data acquired by the sensor is converted into a form more suitable for computation for the microcontroller. On these values, the generation of the bill is done. These values are temporarily stored in Arduino & connect to the ThingSpeak database via a Wi-Fi module on which measured values and bill amount is sent. The following block diagram depicts the proposed prototype of the milk analyser along with database storage.

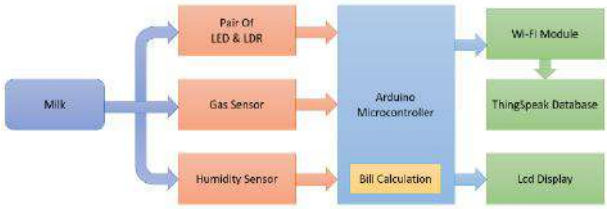

Fig. 1. Block diagram of our proposed prototype

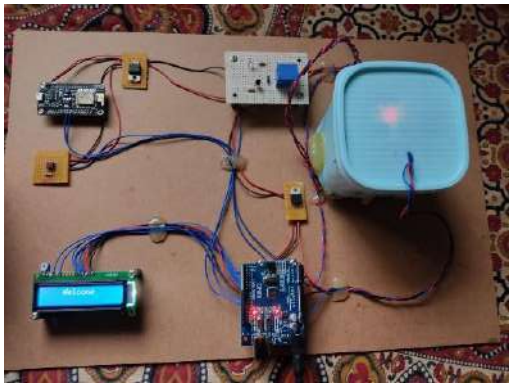

Fig. 2: Proposed Prototype

3.1. INPUT SECTION

The input segment consists of three inputs namely a setup of LED & LDR, a Gas sensor and a Humidity & temperature sensor. This sensor measures the three parameters of our prototype namely, FAT % in the milk, chemical additives added to milk & moisture content of the milk sample.

3.1.1. Setup of LED & LDR

The Fat% is obtained on basis of the light scattered in the milk. The photoresistor, whose resistance varies as the number of incident light varies. Having a high resistance, it is a semiconductor material. Photoconductivity is the

underlying mechanism at play. As more electrons are liberated as the light fades, more charge carriers, such as holes, are produced. The change in resistance brought on by the milk's fat content allows for an analysis of the results.

To receive fat % in a couple of LED & LDR, an external circuit is required to operate the LED for a certain duration the time. The external circuit consists of a relay, transistor & flyback diode. Below is the External circuit that is required for the operation of the led.

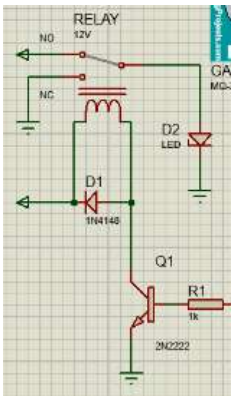

Fig. 3: External Circuit for switching ON/OFF the LED

Once the start button is initiated, the Arduino sends a signal to start the process. The signal to the relay passes the transistor. The relay coil used here is T73 12V DC. The relay coil is switched by an NPN transistor. The transistor is in an open state and thus acts as an open switch and the base voltage is zero. Relay coils are a current device, when no collector current flows through it then there is no current flow through the Base, in this case, the relay coil is de-energized. The current flow between the Base and Emitter i.e., B to E, controls the current flow to the transistor between the Collector to Emitter of the relay coil. The relay coil serves as both an inductor and an electromagnet. A maximum current will flow when electricity is given to the coil as a result of the transistor switching action since the coil has the largest DC resistance, according to Ohm's Law (I = V/R).

A part of this electrical energy is stored in the magnetic field of the relay coil. When the transistor is turned "OFF," the magnetic field decreases thus decreasing the current flow through the relay coil. However, it tries to maintain the current flowing through the relay coil, a reverse voltage arises across the coil because the magnetic field's stored energy must go someplace. This results in a considerable voltage spike across the relay coil that, if allowed to build up, can harm the switching NPN transistor.

Thus, a flywheel diode often referred to as a freewheeling diode, is connected across the relay to guard the semiconductor transistor against damage. To dissipate the stored energy and safeguard the switching transistor, this flywheel diode clamps the reverse voltage across the coil to just under 0.7V. The Arduino is programmed to power the LED for a short duration (2sec) using the external relay circuit. This duration is sufficient for the light to scatter across the container & reach the LDR.

The high beam light from LED is passed through the container that has the milk sample. The high beam light is scattered through the milk & the change in the light beam is received by the LDR. This entire process is taken place inside a Tightly sealed container which has no interaction with the external light. The change in photoconductivity indicates the presence of Fat% content in the milk sample. The incidence of light increases on the LDR, the resistance decreases indicating the Fat% in the milk is lesser and as the resistance increases the amount of Fat% present in milk is more. Thus, LDR generates an output voltage in form of an analog signal which is sent to Arduino to analog input pin A0. The pair of LED & LDR are enclosed inside the container using transparent bottle caps.

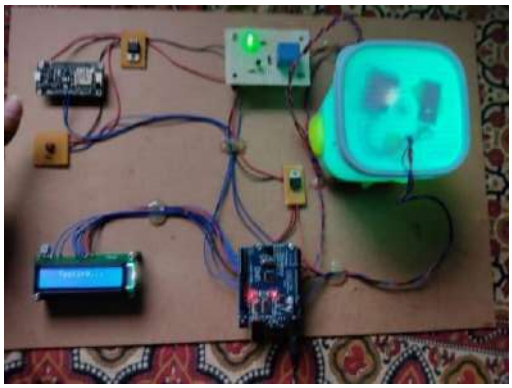

Fig. 4: The testing process of the Milk Analyzer

3.1.2. Gas Sensor

The gas sensor that is used in the prototype is the MQ 2 sensor which detects the presence of Alcohol, Propane, Methane & Carbon Monoxide. When gas contacts the sensing material, its resistance changes, which is the basis for the detection. Gas concentrations are identified by using a voltage divider network.

This sensor has an aluminium oxide foundation with a tin dioxide coating and a ceramic-based detecting component that is encased in a stainless-steel mesh. Six interconnected legs support the sensing element. Two leads do the heat sensing element while the remaining four leads are to provide output signals. The oxygen is adsorbed by the facet of a sensor material when exposed to high

temperature in air. Then, free electrons from tin oxide are influenced by the oxygen, thus arresting the current flow. When the reducing gases are present, the oxygen atoms interact with them and decrease the facet density of the adsorbed oxygen. Analog voltage values were generated because the current is now passing via the sensor. The analogue output voltage of the sensor varies in direct relation to the amount of gas or smoke present. While the output voltage reduces as the gas concentration rises, it increases as gas concentration falls. These voltage readings are taken to determine the gas concentration. When there is a high concentration of gas, voltage levels are greater. These voltage values are fed to the analog input pin A1.

The sensors are used to detect the presence of adulterants present in the container. The insertion of the gas sensor into the milk sample causes damage to the sensor. Hence, it is placed on the lid of the container.

3.1.3. Humidity Sensor

The Humidity sensor used here is DHT11. It is used to detect the freshness of the milk. Using this component, we verify whether the milk is fresh or refrigerated. The DHT11 does the calculation of relative humidity by electrical resistance between two electrodes.

A moisture-holding substrate installed on an electrode surface serves as the humidity sensor for the DHT11. The substrate emits ions as it absorbs water vapour, enhancing the conductivity between the two electrodes. The amount of resistance between the two electrodes varies depending on the relative humidity. The resistance between the electrodes improves with lower relative humidity while it deteriorates with higher relative humidity. The DHT11 converts the resistance measurement which is analog to the relative humidity in digital form which is done by the chip mounted on the back of the unit and transmits the humidity readings directly to the Arduino digital-PWM~ pin 9. Again, the insertion of this module into the milk sample causes damage to the sensor, thus, it is incorporated along with the gas sensor module on the lid of the container.

3.2. MCU (MICROCONTROLLER UNIT)

3.2.1. Hardware

A microcontroller is an integrated circuit with a built-in minicomputer. Microcontrollers are made up of one or more processors, together with peripherals for input, output, and memory. Program memory might be in the form of Read-Only Memory (ROM) or Random Access Memory (RAM). This microcomputer can be utilized in the Internet of Things for data gathering, data actuation, and real-time value sense. For the microcontroller for our prototype, we utilized an Arduino UNO. Based on the ATmega328p microprocessor from Microchip, the Arduino Uno is an open-source microcontroller board made by Arduino.cc. This board for a programmable microcontroller is inexpensive, adaptable, and simple to use.

Signals from the Input section, readings of Fat%, adulterants content and moisture content in the milk are fed to the Pin no A0, A1, and D9 respectively. Using these values, the microcontroller calculates the Bill amount based on the input parameters by programming using the embedded C language. Generation of the bill is done only when the milk sample meets the fixed parameters. Failing to meet one of the parameters, indicating the milk is adulterated. Bill along with the measured parameters is sent to the Wi-Fi module to upload to the database and display them on LCD for the client on spot.

3.2.2. Software

The complete prototype is programmed in embedded C in Arduino IDE. The Arduino IDE is open-source software, which is used to write and upload code to the Arduino boards. It is programmed in such a way that when the MCU receives the three parameters reading, it calculates the bill amount based on the parameters. Failing to meet the parameters generates no result meaning the milk is adulterated. The bill amount along with parameters readings are sent to the Wi-Fi module and display module. The program to connect to a particular network & to transmit, and receive data for the Wi-Fi module is also programmed to the Arduino.

3.3. OUTPUT SECTION

The output segment consists of the ThingSpeak database and the LCD. Bill amount along with parameters is uploaded and displayed respectively.

3.3.1. ThingSpeak Database

ThingSpeak is an open-source software which allows users to communicate with internet-enabled devices. The ThingSpeak Offers an API to both the network websites and the network-enabled devices making data access, retrieval, and logging easier. The output readings from the MCU are stored in the database via a Wi-Fi module. The ThingSpeak stores the data and plots the parameters against the time the test is done. By storing these values, both the vendor & client have the access to the database to monitor the milk flow. Transaction of the amount for the milk can be done weekly or monthly according to convenience.

In this paper, we make use of the NodeMCU ESP8266 Wi-Fi module. NodeMCU is an open-source development board based on the widely used ESP8266 Wi-Fi module. It allows the programmer to program the

ESP8266 Wi-Fi module. The programming language used here is embedded in C. The Wi-Fi module is programmed on how to communicate with MCU on the communication bus and the transfer of data to the ThingSpeak cloud database for data storage. The module is configured to only a particular network to ensure the transfer of data in a secured way. Network username and password are programmed in the MCU. For each individual, a separate channel has to be created that stores the data entries of that particular individual. Multiple channels have to be created to use for multiple clients.

3.3.2. LCD Display

The LCD Unit deployed here is a 16*2 Display. The LCD 16*2 is a type of electronic display that shows information and messages. It has 16 Columns and 2 Rows, as the name would imply, allowing it to show a total of 32 characters (16*2=32).

The Bill amount along with Fat%, adulterant gas & humidity content is displayed for the client. These values are displayed on display at an interval of 5sec. Both the client & vendor get these results on the spot in a matter of sec after the entire process.

3.4. CIRCUIT DIAGRAM

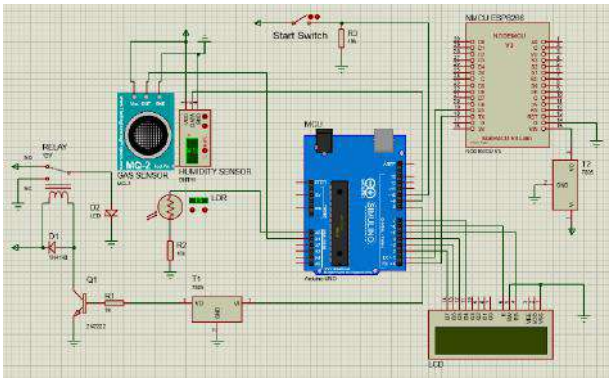

Fig 5: Circuit Diagram of our proposed prototype

IV. EXPERIMENTAL RESULTS

This section briefs about the various tests performed on the variety of cow milk and their corresponding results. To uphold the proper functionality of the system, each component had to be tested individually. To achieve the productive testing of the component, the breadboard and digital multi-meter were used. The testing was performed on each of the components and sections that made up the circuit to ensure the proper and adequate operation of the system.

The milk testing instruments that are available commercially are for the detection of Fat% content in the milk which is expensive. Our prototype produces the same result at a low manufacturing cost. Below are results obtained during the testing of various milk along with adulterants. This chapter is divided into three sections to demonstrate the experimental results of the prototype namely, Validation of Pure Milk, Adulterated Milk & ThingSpeak cloud platform.

4.1. VALIDATION OF PM (PURE MILK)

Below are the pictures obtained during the testing of pure milk.

Fig 6: Fat% of PM

Fig 7: Humidity of PM

Fig 8: Gas Level of PM

Multiple cow kinds of milk were tested and are listed in the below tabular column.

Table I: Validation of PM

Cow No.	Fat% (Measured by the Prototype)	Gas Present (%)	Relative Humidity (%)	Output	Price
C1	9.9	2	71	Normal	31
C2	6.14	2	72	Normal	32
C3	4.63	2	74	Normal	29
C4	4.91	2	73	Normal	29
C5	3.61	1	71	Normal	27
C6	3.06	1	70	Normal	27
C7	4.64	2	74	Normal	29
C8	4.41	2	74	Normal	29

4.2. VALIDATION OF AM (ADULTERATED MILK)

Below are the pictures obtained during the testing of adulterated milk by adding the adulterant to the pure milk.

Fig 9: Fat% of AM

Fig 10: Humidity of AM

Fig 11: Gas Level of AM

Multiple adulterated kinds of milk were tested and are listed in the below tabular column.

Table II: Validation of AM

Cow No.	Fat% (Measured by the Prototype)	Gas Present (%)	Relative Humidity (%)	Output	Price
C1	9.8	9	73	Abnormal	0
C2	6.9	6	79	Abnormal	0
C3	5.37	8	75	Abnormal	0
C4	6.01	9	77	Abnormal	0
C5	5.19	9	75	Abnormal	0
C6	6.35	8	78	Abnormal	0

1.3. THINGSPEAK DATABASE

The entire testing results are updated in the ThingSpeak and are shown below with both the Pure and Adulterated Milk together.

Fig 12: Cloud storage of Fat%

Fig 13: Cloud storage of Humidity

Fig 14: Cloud Storage of Gas

Fig 15: Cloud Storage of Price

V. CONCLUSION

The demonstrated prototype was able to differentiate between adulterated milk and pure milk as shown in Tables I & II. As a result, the designed prototype is compact and portable. It has low power consumption and a fast response time. We can more properly assess milk quality with the aid of this technology, and both clients and vendors will receive regular updates on the milk. Additionally, customers will profit appropriately based on the milk quality, and suppliers will get high-quality milk. Another advantage may be the removal of manual registers used to store all types of information and data.

Our system's measurements of the milk collection characteristics including fat per cent, adulterant, and

humidity produce findings that are comparable to those of older, more sophisticated systems at a lower cost. Simple parts like sensors and NodeMCU are efficiently coupled in the suggested system to help with the administration of diary automation. Thus, the system is portable, easy to use and handle.

Though the Prototype has advantages it also has the limitations such as the determination and Calculation of CLR, and the addition of a pH sensor which enables the further determination of the adulteration. A few of the possible ways to enhance this prototype are mentioned below:

i. Implementing the CLR calculation can enhance further detection of adulterants.

ii. Adding a pH sensor gives the acidity or alkalinity of the milk.

iii. A weight sensor can also be added to calculate the total amount of milk supplied by the client.

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Impact of Foreign Direct Investment on Nigeria's Agricultural Sector (1981 to 2019)

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Abstract— *The need to augment the financial policy interventions of the Central Bank of Nigeria in the agricultural sector is sine qua non. Since agriculture is still the mainstay of Nigeria's economy, its reliance on foreign direct investment (FDI) ought to be ascertained. Consequently, this study investigated the impact of foreign direct investment on Nigeria's agricultural sector. Time series data between 1981 and 2019 were obtained from the databases of the Central Bank and Food and Agriculture Organisation. The Augmented Dickey-Fuller test shows that the variables were I(1). Johansen's co-integration test suggested long-run relationship among the variables. Findings revealed slower acceleration of agricultural productivity (*6.28*) than FDI (17.99). Also, FDI and exchange rate had statistically significant ($p < 0.05$) and negative impact on the agricultural productivity, while implicit price deflator for the agricultural sector had statistically significant ($p < 0.001$) and positive impact on agricultural productivity in the long-run. The error correction term indicates that the speed of adjustment to the short-run equilibrium was high (79.71%). Hence, reliance on foreign direct investment would have adverse effect on agricultural gross domestic product in the long-run. The Federal Ministry of Agriculture and Rural Development should evolve policies that would guarantee steady inflow of foreign direct investment to agriculture in a manner to reverse the negative impact or explore alternatives. In addition, the Central Bank of Nigeria should adopt a sound monetary policy to attain stability in the exchange rate as well as supply of FOREX to ease purchase of agricultural inputs.*

Keywords— ***agricultural finance, growth rate, foreign direct investment, vector error-correction model.***

I. INTRODUCTION

There is no gainsaying that agriculture is the mainstay of Nigeria's economy owing to the preponderance of agricultural activities across the landscape of the country and the contribution of the sector to the overall gross domestic product of the nation. A simple ratio analysis of data from the statistical bulletin of the Central Bank of Nigeria (CBN) shows that, on average, agriculture contributed 23.17% to the overall GDP of Nigeria between 1981 and 2019, rising from only 11.77% in 1981. In Nigeria, because 70% of the population is employed in the agricultural sector, economic growth will be almost impossible to achieve without developing the sector (Odetola and Etumnu, 2013). According to Lawal *et al.* (2018), the role of agriculture in pioneering the growth and development of the nation's economy cannot be overemphasized as it fosters sustainability in economic activities; ensure food security; provide employment to dwellers in rural areas; and reduce poverty; among others. Sekyi *et al.* (2017) added that agriculture continues to be the mainstay of most developing countries in Africa with majority of the people farming at subsistent level with very low incomes. For these reasons, constraints besetting agriculture should be given adequate attention, especially those that relate to financing.

Consequently, various governments have made concerted efforts in the area of agricultural finance to keep the sector afloat. Through the instrumentality of the CBN, series of financial policy interventions have been evolved over time to support the growth of the sector. Some of the interventions include ACGSF (Agricultural Credit Guarantee Scheme Fund); CAADP (Comprehensive African Agriculture Development Program) CRIN (Cocoa Research Institute of Nigeria); EEG (Export Expansion Grant); FSS (farm settlement schemes); NAFPP(National Accelerated Food Production program); OFN (Operation Feed the Nation); RBRDA (River Basin and Rural Development Authorities) (Lawal *et al.*, 2018; Ogbanje *et al.*, 2016).

These efforts were aimed at sustaining increased agricultural productivity. The sector comprises mainly crop, livestock, fishery and forestry production (Abah *et al.*, 2021; Ogbanje *et al.*, 2012). Since the outputs from these subsectors are diverse in nature, several empirical research works (Abah *et al.*, 2021; Ogbanje *et al.*, 2016, 2012) used the gross domestic product (GDP) as a measure of the productivity of the sector. As a matter of fact, the GDP measures the value of production in an economy in a given year. Hence, the agricultural GDP (GDPA) represents the value of production in the entire sector on annual basis. It is noteworthy to state that the GDPA is representative of the GDPs from the subsectors in agriculture.

In addition to home-grown policy support, efforts aimed at capital importation to the sector has enjoyed a boost, the most popular among which is the foreign direct investment (FDI). According to Evans *et al.* (2018), FDI and its probable growth impact especially in developing countries has been a major subject of scrutiny in both the fields of international economics and development. This follows the widespread view that FDI has the potential of positively affecting economic development. According to UNCTAD (1999), FDI is a potent instrument through which economies are integrated at the level of production into the globalizing world economy by bringing a package of assets, including capital, technology, managerial capacities or skills, and access to foreign markets. Awunyo-vitor and Sackey (2018) added that international partnership in form of FDI help countries to be innovative and acquire greater resources to develop, grow and expand their regional economies.

Developing countries lack substantial domestic financial resources to propel the much-needed economic growth. Consequently, FDI is considered a significant source of external funding (Okada and Samreth, 2014). In the quest to lure investors, many governments in Africa have adopted open policies which have made FDI the major and most dependable source of capital inflows in Africa (UNCTAD, 2013). The limelight on developing countries has also been necessitated by its enormous receipt of FDI inflows in recent years. For instance, as global inflows of FDI declined, inflows to developing countries increased. In 2014, inflows to developing countries reached its peak of $681 billion, representing a 2% rise from the previous year (UNCTAD, 2015). Kosova (2010) in UNCTAD (2015) asserted that from the mid-1990s, FDI became the major source of external finance for countries in the developing region, and this accounts for more than twice as large as official development assistance. Lipsey (1999) in UNCTAD (2015) also recounted that FDI has become the most dependable source of foreign investment for developing countries. Data from the Food and Agriculture Organisation (FAO) revealed that Nigeria received the sum of US$100,179.11 million from 1991 to 2019. Awunyo-Vitor and Sackey (2018) added that FDI plays a very significant role in increasing agricultural sector growth by offsetting the investment and technological gaps and facilitating capital formation, owing mainly to limited income and sources of credit.

In spite of the colossal financing of the agricultural sector, there are indications that the sector, as well as the economy itself remains underdeveloped. For instance, Joel (2021) observed that Nigeria's potential for growth and economic stability is yet to be achieved, due to the fact that the economy has witnessed so many shocks and disturbances both internally and externally over the decades. For the agricultural sector, Santangelo (2018) found that FDI in land by developing-country investors negatively influenced food security by decreasing cropland due to domestic institutional pressure to align with national interests and government policy objectives, in addition to negative spillovers.

The foregoing depicts divergent opinions among researchers on the impact of FDI on economic development of critical sectors of developing countries' economies, either in the short-run or long-run. It thus became imperative to contribute to the ongoing debate on the reliance of agricultural sector on international funding. The specific objectives of the study, therefore, were to estimate the growth of FDI and GDPA; determine the long run impact of FDI on Nigeria's agricultural economy; and examine the possibility of short run equilibrium restoration. It was hypothesized that there is no cointegration between FDI and GDPA; and there is no chance of restoration to short run equilibrium. The outcome of the study will be useful in providing policy

direction on the foreign agricultural finance beyond the short-run.

II. METHODOLOGY

The study was carried out in Nigeria, the acclaimed most populous country in Africa and among the black nations of the world as well as among the eight most populous countries in the world (Abah *et al.*, 2021). It is Africa's largest economy as a result of the recent rebasing exercise (Ismail and Kabuga, 2016). The country has a total geographical area of 923,768 square kilometers, comprising land area of 910,768 square kilometers and water area of 13,000 square kilometers. With a population growth rate of 2.6%, Nigeria has an estimated population of 206 million in 2020. Nigeria is located between 4°16 and 13°53 north latitude and between 2°40 and 14°41 east longitude (Central Intelligence Agency [CIA] Fact Book, 2009). It also has a highly diversified agro-ecological climatic condition and hence, agriculture constitutes one of the most important sectors of the economy. The climate varies with Equatorial Guinea in South and Tropical in the Centre and North. There are two seasons – the wet season (April-October) and the dry season (November-March). The type of vegetation is grassland savannah in the North and forest in the south. This vegetation has made agriculture the major employer of labour in the country. Agricultural holdings are generally small and scattered, farming is often subsistence and mostly characterised by simple tools and shifting cultivation. Agricultural farming activities are largely in the hands of smallholder farmers (Hamzat *et al.*, 2006; Ismail & Kabuga, 2016).

Macroeconomic time series data were obtained for the study. While data on agricultural sector GDP, foreign direct investment to the agricultural sector and implicit price deflator were obtained from CBN, data on exchange rate were obtained from FAOSTAT. Descriptive statistics such as mean, standard deviation and coefficient of variation were used for preliminary data analysis. The compound growth model as proposed and employed by Oparinde *et al.* (2017) was also used for the study to estimate the growth rate of the variables for the study. The model is as specified in Equation (1):

$$Y = b_0 e^{bt} \quad (1)$$

Linearising,

$$Log\ Y = b_0 + b_{1t}$$

The growth rate, r is given by

$$r = (e^b - 1) \times 100$$

e is Euler's exponential constant, which is equal to 2.7183

The data were also subjected to pre-estimation tests such as Augmented Dickey Fuller (ADF) test for unit roots, Johansen's maximum likelihood test for co-integration and optimal lag selection. The Johansen test for co-integration test permits more than one co-integrating relationship so is more generally applicable than the Engle–Granger test which is based on the Dickey–Fuller (or the augmented) test for unit roots in the residuals from a single (estimated) co-integrating relationship. In addition, the long-run relationship was estimated using Johansen co-integration technique with normalization restriction imposed. Furthermore, post-estimation tests were carried out. These include lagrange-multiplier test for autocorrelation, Jarque-Bera test for normality, and Eigenvalue stability condition's test.

The aim of the ADF test was to ensure that the data were stationary or have no unit roots, and results of subsequent analyses were not spurious and misleading. Differencing was used to determine the order of integration. If a series is stationary without any differencing, it is designated as I(0), or integrated of order 0. On the other hand, a series that has stationarity at first differences is designated I(1), or integrated of order one (1). The formula for unit root test using ADF was specified in Equation (2):

$$\Delta X_t = \alpha_0 + \sigma X_{t-1} + \sum \beta \Delta X_{t-1} + e_t \quad (2)$$

where:

X_t = current values of variables;

X_{t-1} = immediate past values of variables;

Δ = difference operator

α, σ, and β = parameters to be estimated

e = error term

The test statistics of the estimated coefficient of Y is then used to test the null hypothesis that the series is non-stationary (has unit root). If the absolute value of the test statistics is higher than the absolute value of the critical value (which could be at 1, 5, or 10 percent) then the series is said to be stationary, therefore we would reject the null hypothesis, otherwise it has to be differentiated until it becomes stationary. The econometric technique adopted was based on the Johansen maximum likelihood estimation procedure and the vector error correction model (VECM). While the former helps to determine cointegration rank of the model, the later helps to ascertain the possibility of error correction as the model approaches its long run equilibrium path.

The choice of a cointegration technique over the ordinary least square techniques lies on the following: i. most time series data are not stationary, implying that the

assumption of a constant mean, a constant variance and a constant auto variance for every successive lag is mostly violated, so the use of the OLS method of estimation could only yield a spurious result. ii. Cointegration approach is a convenient approach for the estimation of long run parameters. iii. The cointegration approach provides a direct test of the economic theory and enables utilization of the estimated long run parameters into the estimation of the short run disequilibrium relationships. iii. The traditional approach is criticized for ignoring the problems caused by the presence of unit roots in the data generating process. However, both unit root and cointegration have important implications for the specification and estimation of dynamic models (Awunyo-vitor and Sackey, 2018; Evans *et al.*, 2018; Ogundipe *et al.*, 2014; Omorogiuwa *et al.*, 2014). The model for long run relationship is as specified in Equation (3):

$$\Delta lngdpa_t = \sigma + \sum_{i=1}^{k-1} \beta_1 \Delta lngdpa_{t-i} + \sum_{m=1}^{k-1} \varphi_m \Delta lnfdia_{t-m} + \sum_{n=1}^{k-1} \emptyset_j \Delta lnexr_{t-n} + \sum_{p=1}^{k-1} \emptyset_j \Delta lngipd_{t-p} + \lambda_1 ECT_{t-1} + \mu_{1t} \quad (3)$$

where:

GDPA = Agricultural sector Gross Domestic Product (₦ billion); FDIA = Foreign Direct Investment to agricultural sector (₦ billion); EXR = Exchange rate of naira to dollars (%); GIPD = Gross Domestic Product implicit price deflator (%).

K – 1 = lag length

β,φ,ϕ, = short-run dynamic coefficients of the model's adjustment to long-run equilibrium

λi = speed of adjustment parameter which comes negative sign to ensure convergence to long-run

ECT_{t-1} = the error correction term which is the lagged value of the residuals obtained from the long-run

U_{it} = stochastic error term called impulses or innovations or shocks

The control variables in the model were exchange rate, implicit price deflator for the agricultural sector. The exchange rate was included as control variable because, according to Ogundipe *et al.* (2014), exchange rate affects the value of FDI inflow into the economy. It is the amount of money contractually promised at a certain specified future dates as a proportion of the principal borrowed. Similarly, the inclusion of the implicit price inflation was based on the belief that it affects the real value of agricultural productivity.

III. RESULTS AND DISCUSSION

The analysis of the descriptive statistics of the variables in the systems equation was presented in Table 1. The result shows that the variable with the highest coefficient of variation within the period under review was FDIA (2.50 %). This implies a large variation, invariably fluctuation, in FDI inflow to the agricultural sector. This could affect planning and projections of agricultural sector output and outcomes. The variable with the least coefficient of variation was GDPA (0.67 %), the target variable in the study. This result implies some level of stability over time. It could also mean slow growth.

Table 1: Descriptive Statistics of Variables

Statistics	Mean	Minimum	Maximum	Standard deviation	Coefficient of variation
GDPA	7,956,731.00	2,303,505.00	18,000,000.00	5,349,728.00	0.67
FDIA	18,800,000,000.00	117,000,000.00	198,000,000,000.00	47,000,000,000.00	2.50
EXR	99.92	0.62	306.92	89.62	0.90
GIPD	54.41	0.71	202.01	59.90	1.10

Source: Computed with data from CBN and FAO databases

Growth rate

The analysis of the growth rate of the variables in the study was presented in Table 2. The result shows that the quadratic time t^2 for LNGDPA, FDIA, EXR and GIPD was positive and statistically significant ($p<0.01$). According to Amos & Ayanda (2004) and Oparinde *et al.* (2017), this result implies significant acceleration. The result further revealed that GDPA had a very slow growth

rate (6.28%). This is a confirmation of the declining agricultural productivity which has been variously reported. It is a result of the myriads of the constraints, including government's neglect, affecting the sector, notwithstanding its importance to the economy.

FDIA and EXR exhibited similar acceleration. However, it is noteworthy that the naira gained and sustained its free fall against the dollar during the period under investigation. Akinbode & Ojo (2018) had stated there have been fluctuations in the exchange rate of the ₦aira to other major world currencies especially the US Dollar over time. According to Alori & Kutu (2020), the upsurge was exasperated by the introduction of both dollars pegged systems and managed float of exchange rate policies in the Nigerian economy. Increasing exchange, invariably declining value of the ₦aira has the potential to discourage current and potential investors because it heightened uncertainty over the return on investment. In addition, an accelerating exchange rate makes it difficult for farmers to purchase production inputs like herbicides and fertilizers as well as farm assets like the knapsack sprayer and tractor. Similarly, the costs of various operations increase and reduce the scale of operation, thereby inhibiting productivity.

For GIPD, the result is outrageous. As a measure of inflation, the result is an empirical representation of the galloping food inflation in the economy as food prices are going beyond the reach of an average Nigerian. This result suggests some form of neglect in the management of inflation by appropriate authorities.

Table 2: Growth Rate

Variables	Coefficient (b)	t-value	R^2	Growth rate, r (%)
LNGDPA	0.0609	33.28*	96.77	6.28
LNFDIA	0.1654	10.46*	74.72	17.99
LNEXR	0.1596	13.58*	83.29	17.30
LNGIPD	4.8843	15.36*	86.44	13,120.22

* statistically significant growth

Source: Computed with data from CBN and FAO databases

Stationarity test

The result of the stationarity test was presented in Table 3. At levels and as specified in equation (2), the absolute values of the variables were less than the critical values at 5%. This implies that the variables had unit roots at level [I(0)]. This submission is in line with Awe (2013) and Anwana & Affia (2018). A further proof of the presence of unit roots in the series is that the R^2 (0.9515) was greater than the Durbin-Watson statistic (0.3366) in the spurious regression of the variables in their levels form. Under this scenario, the variables were deemed to be non-stationary.

However, the variables became stationary in their first differences [I(1)]. The basis is that the absolute values were greater than the critical values at 5% level. The decision conforms with Aminu (2020) and Afolabi *et al.* (2021). The models were dictated by the nature of the trend in their line graphs as stipulated by Gujarati (2003). Furthermore, in their first differences, the regression result shows that R^2 (0.0336) was less than the Durbin-Watson statistic (1.9553). These results imply that the variables were stationary in their first differences.

Table 3: Stationarity Test

	At level I(0)		At first difference I(1)	
Variable	Test statistic (Z(t))	5% Critical value	Test statistic (Z(t))	5% Critical value
GDPA	-2.003	-3.552	-4.378	-3.556
FDIA	-1.365	-1.691	-7.679	-1.692
EXR	-1.46	-3.552	-3.708	-3.556
GIPD	-1.44	-1.691	-2.683	-1.692

Source: Computed with data from CBN and FAO databases

In addition, the line graphs of the series in their levels form, as shown in Figure 1, show that the variables were largely trending upwards and failed to revolve around zero. Thus, they can be said to have unit roots. But in Figure 2, the line graphs exhibited mean reversion, implying that they became stationary after their first differencing.

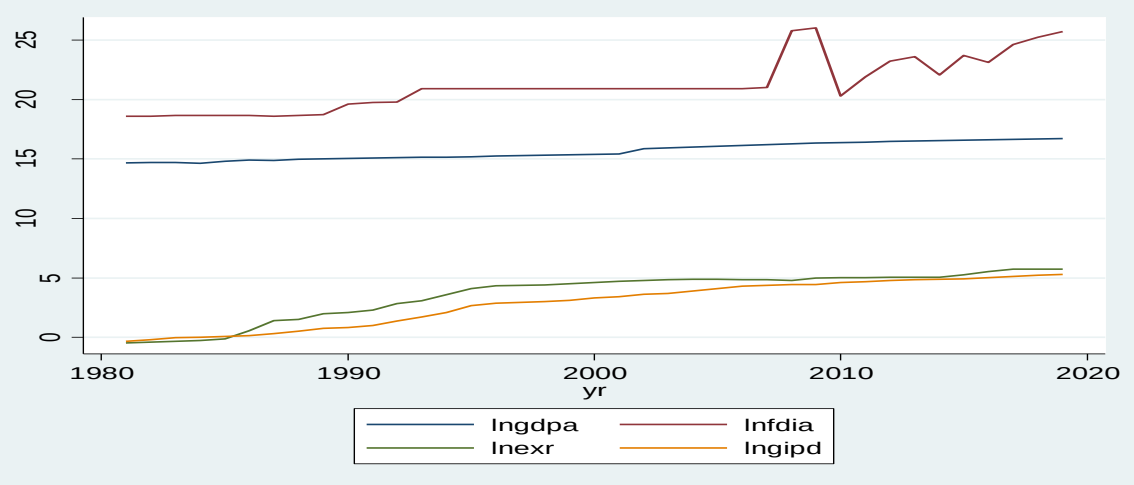

Fig.1: Line graphs for the variables at their levels form

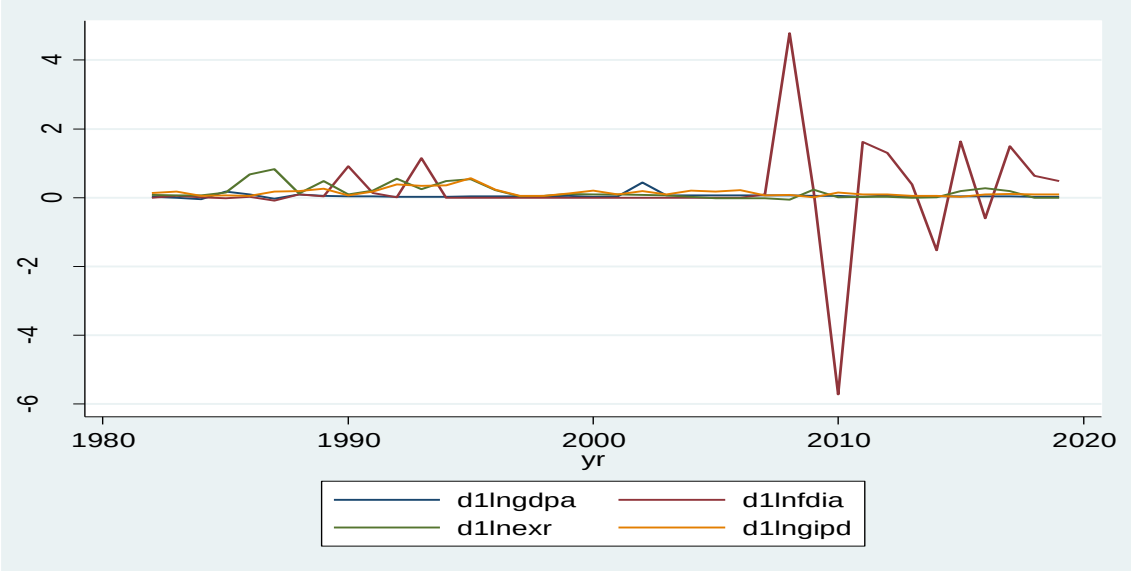

Fig.2: Line graphs for the variables in their first differences

Johansen Maximum Likelihood Test of Co-integration

The result of Johansen's test of co-integration was presented in Table 4. The essence of this test was to confirm the existence or otherwise of long run relationship. The result shows that the first null hypothesis of no co-integration was rejected because, at 5%, the trace statistic (51.0903) was greater than the critical value (47.21). This was in line with Ismaila & Imoughele (2015), Victor (2015), Ismail & Kabuga (2016) and Osabohien *et al.* (2019).

The study, however, failed to reject the second null hypothesis of at least one co-integrating equation because the trace statistic (28.2633*) was less than the critical value (29.68). These results were corroborated by the maximum statistics. The confirmation of co-integration implies that there is a long-run relationship among the variables in the system equation (Andrei & Andrei, 2015; Akinkunmi, 2017). In other words, there is cointegration between FDI and GDPA. The result paves way for the estimation of long-run relationship with vector error-correction model.

Table 4: Johansen Maximum Likelihood Test of Co-integration

Null hypothesis	Trace statistic	5% Critical value	Maximum statistic	5% critical value
0	51.0903	47.21	22.827	27.07
1	28.2633*	29.68	13.6368	20.97
2	14.6265	15.41	9.3072	14.07
3	5.3193	3.76	5.3193	3.76

* Available co-integrating equations

Source: Computed with data from CBN and FAO databases

Optimal Lag Selection

In Table 5, six optimal lag selection criteria were used namely, LL, LR, FPE, AIC, HQIC, and SBIC. The result shows that LR, FPE, AIC, HQIC and SBIC recommended one lag. The bases were the asterisk from the software and the concept of the least the value the better. Hence, the estimation of vector error-correction model will use one lag as suggested and implemented by (Adongo *et al.*, 2020).

Table 5: Optimal lag selection

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-126.021				0.019808	7.42976	7.49112	7.60751
1	49.9946	352.03*	16	0.001	2.1e-06*	-1.71398*	-1.40717*	-0.825206*
2	62.0176	24.046	16	0.089	2.80E-06	-1.48672	-0.93448	0.113064
3	65.9292	7.8231	16	0.954	6.20E-06	-0.79595	0.001735	1.51485
4	73.8225	15.787	16	0.468	0.000012	-0.33271	0.710417	2.6891

* Recommended lag criteria

Source: Computed with data from CBN and FAO databases

Estimation of long-run relationship with Johansen normalization restriction imposed

The result of vector error-correction model was presented in Table 6, with Johansen normalization restriction imposed on the GDPA. The chi-square statistic (131.6573) for the overall co-integrating equations was statistically significant ($p < 0.01$). This marked the final confirmation of the presence of long run relationship in the systems equation. The result also shows that lag one of the natural logarithms of FDIA, EXR and GIPD had asymmetric and statistically significant ($p < 0.01$) impact on agricultural sector GDP in the long-run.

Specifically, lag one of the log of FDIA had negative impact on the agricultural GDP since the z-statistic (3.08) was statistically significant ($p < 0.05$). Hence, a 1% increase in FDIA would reduce agricultural sector GDP by 0.2678 % in the long-run. This result further implies that FDIA and GDPA would move in different directions in the long-run. The injection of foreign capital into the agricultural sector resulted in negative outcome in the sector because of the large coefficient of variation that was observed in this study. Within the context of neoclassical growth models, the reason could be attributed to the possibility of diminishing marginal returns to capital. According to Evans *et al.* (2018), FDI can only have effect on the level of income without affecting long run growth rate. In other words, the probable effect of FDI on growth is limited to the short-run, and the extent of the effect depends on the transitional dynamics to the steady-state growth path. Epaphra and Mwakalasya (2017) also found that there was no significant effect of FDI inflows on agriculture value added-to-GDP ratio in Tanzania despite the fact that FDI inflows in economy was outstanding particularly between 1990 and 2015. However, the finding of this study is at variance with Awunyo-vitor and Sackey (2018) who found a positive and significant relationship between economic growth and foreign direct investment flow to the agricultural sector and volume of trade in Ghana. The difference in the impact of FDIA on agricultural sector across these African countries can be attributed to

differences in policies and level of technology available and adoption.

Furthermore, lag one of the log of exchange rate had negative impact on the agricultural sector GDP since the z-statistic (4.59) was statistically significant ($p < 0.001$). Hence, a 1% increase in exchange rate would reduce agricultural sector GDP by 0.7974% in the long-run. This result further implies that exchange rate and agricultural sector GDP would move in different directions in the long run. Increase in exchange rate is synonymous with declining value of the local currency and invariably with the declining growth rate of the economy. In other words, a relatively large volume of the local currency (the naira) would be required to obtain a given volume of dollars, for instance. Hence, the price of imported agricultural inputs would be high. Also, as long as the exchange rate increases, the growth of the agricultural sector economy would decrease. As noted by Ogundipe *et al.* (2014), the conservative monetary management policies put in place for stabilizing the exchange rate of a unit U.S dollar to naira over the years would have been ineffective. Consequently, Zehra *et al.* (2019) stated that the adoption of flexible exchange rate regime among others, have made central banks around the globe to be more concerned about money demand. This was probably intended to ameliorate agricultural financing challenges. To this end, Onyiriuba *et al.* (2020), in a study of government policies in agricultural financing, asserted that the authorities seek to get rid of bottlenecks, ease participation and redress constraints on access to finance in agriculture through policy interventions as a means of sustainable economic growth. The finding of this study is inconsistent with Adeniran *et al.* (2014) who found that exchange rate had positive but insignificant effect on Nigerian economic growth between 1986 and 2013.

Finally, lag one of the log of implicit price deflator for the agricultural sector GDP had positive impact on agricultural GDP in the long-run since the z-statistic (-7.53) was statistically significant ($p < 0.01$). Hence, a 1% increase in GIPD would increase GDPA by 1.5939%. The inverted sign of the variable implies that GIPD and GDPA would move together in the long-run. Normally, inflation increases and pushes the value of commodities beyond the reach of an average income earner. In this case, the valuation of GDPA would be high. This finding is in conformity with Olatunji *et al.* (2012) that there was direct relationship between agricultural output change and inflation rate in Nigeria between 1970 and 2006. Similarly, Oyinbo and Rekwot (2014) found that there was a unidirectional causality from inflationary trend to agricultural productivity.

Table 6: Long-run relationship with Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
lngdpa	1	.	.	.	.	.
lnfdia	0.267802	0.086934	3.08*	0.002	0.097414	0.43819
lnexr	0.797387	0.173884	4.59*	0.001	0.456581	1.138193
lngipd	-1.59397	0.21163	-7.53*	0.001	-2.00875	-1.17918
_cons	-19.7855	.	.	.	.	.

chi2 = 131.6573; P>chi2 = 0.0000; * Statistical significance at 0.01 level

Source: Computed with data from CBN and FAO databases

The Vector Error Correction Model

The result of the vector correction model (VECM) for the study was presented in Table 7. The ECM coefficient is known as the speed of adjustment factor. It estimates how fast the system can adjust to restore equilibrium. According to Arize (2003), the ECM therefore reflects how the system converges to the long run equilibrium. Rashid & Jehan (2014) used the VECM to estimate the speed at which the variables converge to its long-run equilibrium. According to Gujarati & Porter (2009), the model also captures the reconciliation of the variables over time from the position of disequilibrium to the period of equilibrium as much as possible. The basic criteria for analyzing VECM, according to Ogundipe *et al.* (2014), are (i) that the ECM must lie between 0 and 1; (ii) it must be negative for it to be meaningful. If it's positive there is no error correction and therefore diverges; and (iii) the t-statistic (or z-statistic) must be at least two and significant to confirm the possibility of restoration due some shocks.

Table 7: Vector Error Correction Model

Variables	ECM (-1)	Std. Err.	z	P>|z|	[95% Conf. Interval]	
D_lngdpa	-0.02023	0.020904	-0.97	0.333	-0.0612	0.02074
D_lnfdia	-0.79713	0.37076	-2.15*	0.032	-1.52381	-0.07045
D_lnexr	0.1892	0.052414	3.61	0.001	0.086471	0.291929
D_lngipd	0.111265	0.027279	4.08	0.001	0.057798	0.164731

*** Correctly signed and statistically significant at 0.05 level**

Source: Computed with data from CBN and FAO databases

The speed of adjustment co-efficient for FDIA is -0.79713. The ECM for FDIA was correctly signed and, in terms of magnitude, lies between 0 and 1. Furthermore, the z-statistic was above 2 and statistically significant ($p < 0.05$). Hence, the study rejected the null hypothesis of no possibility of restoration to short run equilibrium. Consequently, the model has the capacity to correct errors generated in the immediate past periods as it approaches its long run equilibrium path. Precisely, the error correction model in this study implies that about 79.71% of errors generated between each period are correlated in subsequent periods while 20.29% are uncorrelated. The speed of adjustment to the short run, in order to restore equilibrium, is as high as 79.71%. Since errors are short lived in our model, it implies that the long run relationship obtained is sustainable and this result is reliable.

Postestimation test

Three postestimation tests namely, autocorrelation, normality and stability conditions were carried out. In Table 8, the lagrange-multiplier test shows that there was no autocorrelation of errors in the systems equation. The result of the Jarque-Bera Test for normality was presented in Table 9. The result shows that the errors were normally distributed for EXR and GIPD but not for GDPA and FDIA. Overall, the errors are not normally distributed. The result of the Eigenvalue stability condition was presented in Table 10. The result shows that the systems equation was stable. In addition, the VECM specification imposed 3-unit moduli.

Table 8: Lagrange-multiplier Test for autocorrelation

lag	chi2	df	Prob > chi2
1	5.4121	16	0.99329
2	8.0692	16	0.94678

H0: no **autocorrelation** at lag order

Table 9: Jarque-Bera Test for normality

Equation	chi2	df	Prob > chi2
D_lngdpa	464.025	2	0.0001
D_lnfdia	29.861	2	0.0001
D_lnexr	1.307	2	0.52032
D_lngipd	2.496	2	0.28709
ALL	497.689	8	0.0001

Table 10: Eigenvalue stability condition

Eigenvalue	Modulus
1	1
1	1
1	1
0. .7398102	0. 73981

IV. CONCLUSION

The study determined the impact of foreign direct investment on Nigeria's agricultural sector, using time series data from 1981 to 2019. From the results of the study, it can be concluded that reliance on foreign direct investment would have adverse effect on agricultural gross domestic product in the long-run. This submission could be due the instability of foreign direct investment inflow within the period. Improper utilization, as is the case with agricultural finance interventions, is also suspect. The impact of foreign direct investment would have been worsened or masked by the outrageous growth in inflation and free fall of the naira as exemplified by a high growth rate. However, available statistical evidence shows that there is a high speed of adjustment to the short run equilibrium.

RECOMMENDATIONS

The Federal Ministry of Agriculture and Rural Development should evolve policy that would attract

steady inflow of foreign direct investment to agriculture so that in the long-run the negative impact can be forestalled. It is also imperative to commence the exploration of agricultural financing to FDI. The monetary authority should collaborate in this effort by ensuring that high exchange rate and outrageous inflation do not discourage both current and prospective foreign investors. Apart from the empirical basis, this recommendation arose from the obvious fact that supplementary agricultural financing to augment domestic funding would be necessary in a long time to come.

In addition, Central Bank of Nigeria should adopt a sound monetary policy to attain stability in the exchange rate as well as supply of FOREX as they relate to the agricultural sector. This will ensure that exchange rate movement favours growth in the agricultural sector. Finally, measures to absorb excess agricultural output and cautiously finance the sector should be developed by the Federal Ministry of Agriculture and Rural Development in conjunction with the Central Bank of Nigeria. These measures will ensure stability in food prices and inflation in a manner that will facilitate growth in the value of agricultural productivity in Nigeria.

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Study of Physico- Chemical Parameters of Sugar Industry Effluent

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Abstract— *Sugar mill effluents are responsible for deterioration of water quality, due to effluents physical and chemical characteristics of river water changes and become unfit for human consumption. The present study was undertaken on the physico-chemical parameters of Bhima-Patas sugar industry effluent in Daund Tahsil. The study was conducted during 2009-2012 in crushing season of sugar industry. During the study period we recorded the different Physical as well as chemical properties of sugar mill effluent like Temperature, pH, TSS, TDS, Hardness, BOD, COD, DO, SO_4, PO_4, Oil and Grease, Zn, Hg etc. The result from the analysis of sugar industry waste water (effluent) shows that most of the parameters were much higher than the Minimum Pollution Level (MPL). Hence the flow of this effluent into the river causes serious pollution problems for aquatic life as well as human and livestock.*

Keywords— ***Effluent, Pollution, Temperature, pH, etc.***

I. INTRODUCTION

According to survey conducted by NEERI 70% of India's fresh water is polluted by industrial effluents. Aquatic pollution has resulted in the disintegration of flora and fauna. Types of water pollution may be due to inorganic pollutant, enrichment with phosphate, sulphate, nitrate, trace elements like Hg, Cd, Pb, As, Se, Zn etc. pesticides and fertilizer Philip Weinberg (1992) and Jadhav (1995).

The World Bank has listed sixty-four industries which are highly polluting, distilleries being at the top and sugar industries ranked second. In Maharashtra there are 207 sugar industries which have a crushing capacity of 4.78 lakh metric ton per day. Sugar industry is basically a seasonal industry in nature and operates only 120-210 days in year (Nov-May), a significantly large volume of waste water is generated during production of sugar, which contain high amount of pollution load particularly in terms of TDS, TSS, DO, Organic matter, fresh mud bagasse and air pollutant.

When this effluent discharged and mixed into water bodies, the quality of water and aquatic life get changed. The need for investigation of the sugar factory effluents was concerned by many researchers from India and abroad and has conducted a series of investigations and gave fruitful results. Varma and Shukla (1969) and Essink (1978) have found that the effluent released by sugar industry produced a high degree of organic pollution in the aquatic ecosystem.

According to Coroni (1975) the effluent discharge by sugar industry having high BOD affects the aquatic life due to significant decrease in dissolved oxygen. Pondhe *et al.,* (1982) studied the impact of sugar mill effluents in rivers and ground water and found that the water quality was changed due to mixing of sugar mill effluent. Kudesia and Verma (1985) reported sugar mill effluent contain high BOD and organic matter. Behera and Missra (1985) have found that the sugar mill effluents are disturbing the ecological cycle of living organism in aquatic ecosystem. Kohar *et al.,* (1991) have studied the threat of aquatic life by the effluents of sugar industry. They found that due to depletion of dissolved oxygen in water by the effluents create anoxic condition which is unsuitable for aquatic life. Chauhan (1991) reported that TSS is harmful parameter in the effluent of sugar factory become causative agent for toxicity in the river and ground water in which they get

mixed. Present study the samples of sugar industry were collected and analyzed for various physico-chemical parameters. Many researchers from India and other countries have under taken studies on sugar mill effluent in their particular area from time to time. No previous published work regards to sugar industrial effluents from same region hence we conducted this study.

II. MATERIAL AND METHODS

Study area:

Study was conducted during 2009 to 2012 from sugar industry Bhima- Patas, during crushing season.

Methodology:

The effluent samples were collected every month during crushing season for the study period at 7 to 8 am in glass jars and analysed as suggested by APHA (2000). Samples were analyzed periodically for physico-chemical characteristics. The temperature of water sample was recorded on the field itself with the help of centigrade thermometer. The pH of effluent and river water measured immediately after collection of the sample. pH of the sample was measured on the digital pH meter using glass electrode by Electrometric method. TDS and TSS were analysed by Gravimetric method. Hardness measured by EDTA Titrimetric method. Biochemical oxygen demand (BOD) was calculated by Titrimetric methods. Chemical oxygen demand (COD) was measured by Redox method. Dissolved Oxygen (DO) was measured by Winkler's iodometric mehod. Phosphate and sulphate were measured by stannous chloride and Turbidimetric methods respectively, Zinc calculated by Zincon method (APHA, 2000), Mercury and Arsenic measured by Colorimetric method (APHA, 2000).

III. RESULT AND DISCUSSION

The effluents of sugar industry have high pollution load mainly in terms of pH, TSS, Total Hardness, COD, BOD, DO and SO_4.Generally amount of wastes water generated in a sugar factory ranges from one thousand to two thousand metric cube per day (Verma & Shukala; 1969). The physico-chemical parameters enable us to understand and estimate pollution level of the effluent on the environment.

The effluent sample was collected from selected sampling station on the main stream of the sugar industry during crushing season i.e. 2009-2010, 2010-2011 and 2011-2012. The samples were analyzed in laboratory by the standard methodology of APHA (2000). The following physico-chemical parametric results were obtained in the cluster of sugar industrial effluent and are recorded in table no. 1, 2 and 3 respectively.

Table 1 Physico-chemical values of Sugar Industry effluent during the year 2009-2010

Parameters	Nov 09	Dec 09	Jan 10	Feb 10	Mar 10	Apr 10	Permissible discharge limit (IS:2490)
Temp of Eff (^{0}C)	41	41	42	40	41	42	Not more than 40 ^{0}C
Ph	5.70	5.60	4.90	5.20	4.35	4.0	5.5 - 9.0
TSS	260	245	320	266	230	240	100 mg/l
TDS	980	1370	1200	1030	1790	1530	2100 mg/l
Total hardness	270	450	846	981	995	754	200-500
BOD	900	1167	1360	1290	1435	1516	100 mg/l
COD	1675	1979	2455	2310	2540	2569	250 mg/l
DO	NIL	NIL	NIL	NIL	NIL	NIL	_
PO_4	8.0	9.4	10.35	10.0	11.70	11.80	_
SO_4	140	180	210	213	217	260	100 mg/l
Oil & Grease	NIL	NIL	NIL	NIL	NIL	NIL	10 mg/l
Zn	6.9	6.0	6.5	6.3	7.0	7.5	1 5 mg/l
Hg	NIL	NIL	NIL	NIL	NIL	NIL	0.01 mg/l
As	0.013	0.015	0.024	0.015	0.02	0.024	0.2mg/l

(All the values are in mg^{-L} except Temp. and pH.)

Table 2 Physico-chemical values of Sugar Industry effluent during the year 2010-2011

Parameters	Nov 10	Dec 10	Jan 11	Feb 11	Mar 11	Apr 11	May 11	Permissible discharge limit (IS:2490)
Temp of Eff (^{0}C)	40	40.5	40.5	42.5	43	44.5	46.5	Not more than 40 ^{0}C
pH	6.8	5.9	5.6	4.1	4.4	4.3	3.7	5.5 - 9.0
TSS	105	125	145	180	260	390	340	100 mg/l
TDS	450	645	680	776	620	610	995	2100 mg/l
Total hardness	327	383	655	752	990	830	860	200-500
BOD	1020	1200	1430	1890	1950	2960	4650	100 mg/l
COD	2000	2340	2630	3560	3735	4220	7800	250 mg/l
DO	NIL	NIL	NIL	NIL	NIL	NIL	NIL	_
PO_4	6.38	7.40	7.60	11.20	11.50	12.10	13.0	_
SO_4	90	157	225	340	380	320	310	100 mg/l
Oil & Grease	NIL	NIL	NIL	NIL	NIL	NIL	NIL	10 mg/l
Zn	5	5	5.5	6	6.5	7	8	1 5 mg/l
Hg	NIL	NIL	NIL	NIL	NIL	NIL	NIL	0.01 mg/l
As	0.015	0.020	0.02	0.025	0.030	0.035	0.040	0.2mg/l

(All the values are in mg^{-L} except Temp and pH.)

Table 3 Physico-chemical values of Sugar Industry effluent during the year 2011-2012

Parameters	Nov 11	Dec 11	Jan 12	Feb 12	Mar 12	Apr 12	Permissible discharge limit (IS:2490)
Temp of Eff (^{0}C)	40	41.5	41	43	44	45	Not more than 40 ^{0}C
pH	5.0	4.8	4.8	4.3	4.1	4.0	5.5 - 9.0
TSS	100	110	170	185	195	215	100 mg/l
TDS	500	515	650	670	585	610	2100 mg/l
Total hardness	345	440	475	600	590	660	200-500
BOD	1010	1070	1200	1390	1740	1800	100 mg/l
COD	1420	1615	1880	2135	3035	3250	250 mg/l
DO	NIL	NIL	NIL	NIL	NIL	NIL	_
PO_4	6.6	7.5	8.5	9.0	9.0	10.	_
SO_4	110	140	180	205	230	245	100 mg/l
Oil & Grease	NIL	NIL	NIL	NIL	NIL	NIL	10 mg/l
Zn	2.5	3.5	4.2	6.0	5	5.6	1 5 mg/l
Hg	NIL	NIL	NIL	NIL	NIL	NIL	0.01 mg/l
As	0.019	0.018	0.020	0.026	0.029	0.024	0.2mg/l

(All the values are in mg^{-L} except Temp and pH.)

Temperature: -

Temperature is the primary environmental factor that affects the biological activities and solubility of gases. The mean values of temperature of the effluent ranged from 40-42^{0}C, 40-46.5^{0}C and 40-45^{0}C during 2009-2010, 2010-2011 and 2011-2012 respectively, the highest temperature was recorded 46.5^{0}C in May 2011 & lowest 40^{0}C in Nov 2010. (Table No.2). High values of temperature show the presence of fewer amounts of dissolved gases, which make water tasteless and less palatable (Trivedy et al., 1986).

pH:-

The mean values of pH of the effluent ranged from 4.0-5.7, 3.7-6.8 and 4.0-5.0 during 2009-2010, 2010-2011 and 2011-2012 respectively. pH was found lowest 3.7 during May 2011 and it was higher 6.8 in Nov 2010. (Table No. 2). pH of water is proved to be important ecological factor which controls the activities and distribution of aquatic flora and fauna (Verma & Shukla 1978). The alteration in pH of water is accompanied by changes in physico-chemical aspects of the medium. pH of medium changes due to human activities in and around it (Zutshi *et al.*, 1973) and (Singh, 1986).

Total suspended solids (TSS):-

TSS is more harmful parameters in the effluents of sugar industry. They cause toxicity in the river and ground water in which they get mixed (Chauhan, 1991). The values of TSS of sugar industry effluents ranging from 230-320mg/l, 105-390 mg/l and 100-215 mg/l during the crushing seasons 2009-2010, 2010-2011 and 2011-2012. The highest TSS was recorded at 390 mg/l during April 2011 and lowest 100 mg/l in Nov 2011. (Table no.2 &3)

Total dissolved solids (TDS):-

Effluents of sugar factory contain appreciable amount of total dissolved solids. It includes salts of variety of organic substance. The dissolved solids normally confer a degree of hardness to water. A value of TDS was found in the effluent ranging from 980-1790 mg/l, 450-995 mg/l and 500-670 mg/l during 2009-2010, 2010-2011, and 2011-2012 respectively. The highest TDS was recorded 1790 mg/l during March 2010 and lowest 450 mg/l in Nov 2010. (Table No.1 and 2). Effluent having high TDS is harmful for irrigation and disposal on land, high amount of solids in the effluents increase their toxicity as they do not support any life them (Maid and Shimpi, 1984).

Total hardness: -

The values of Total hardness of the effluent were recorded ranging from 270-995 mg/l., 327-990 mg/l and 345-660 mg/l during 2009-2010, 2010-2011 and 2011-2012 respectively, the highest total hardness was recorded 995 mg/l during March 2010 and lowest 270 mg/l in November 2009. (Table No.1)

Bio-chemical oxygen demand (BOD): -

BOD of the effluents increases with temperature and decreases as the sedimentation of waste take place (Baruach*et al;* 1993). BOD values decrease as the effluent flow longer distances (Avash Maruthi, 2000). BOD is an important parameter which shows the level of biological pollution of the effluents. The mean values of BOD of the sample were collected have been recorded in tables and found ranging 900-1516 mg/l, 1020-4650 mg/l, 1010-1800 mg/l during 2009-2010, 2010-2011 and 2011-2012 respectively. BOD was maximum 4650 mg/l during May 2011 and lowest 900 mg/l in Nov 2009. (Table No.2 & 1)

Chemical oxygen demand (COD): -

High COD can result into infertile of soil due to lowering of the amount of carbon, nitrogen and phosphorous (Trivedi and Shinde, 1983). Effluents with high COD cause toxic effects on aquatic biota (Chauhan, 1991). The COD values found ranging 1675-2570 mg/l during 2009-2010 & 2000-7800 mg/l during 2010-2011 and 1420-3250 mg/l during 2011-2012. COD was found highest 7800 mg/l during May 2011 and lowest 1675 mg/l in Nov 2009. (Table no.2 &1)

Dissolved oxygen (DO):-

Dissolved oxygen is one of the most important parameters in determining water quality. The existence of aquatic life depends upon concentration of oxygen in water. The value of dissolved oxygen in the sample collected is almost zero. It is also noticed that dissolved oxygen was decrease with increase in temperature and contamination of organic matter.

Phosphate and Sulphate (PO_4 and SO_4):-

The value of Phosphate in the effluent was found in the range 8.0-11.80 mg/l, 6.38-13 mg/l and 6.6-10 mg/l during 2009-2010, 2010-2011, 2011-2012 respectively.

The maximum value of phosphate 13 mg/l was recorded in May 2011 & minimum 6.38 mg/l was found in Nov 2010. (Table No.1&2)

Sulphate content in the effluents ranged 140-260 mg/l during 2009-2010, 90-380 mg/l in 2010-2011 and 110-245 mg/l during 2011-2012. The maximum value of sulphate 380 mg/l was recorded in March 2011 & minimum 90 was found in Nov 2010 (Table No.2). Wetzel (1975) concluded that phosphorus was most important factor bringing about eutrophication and algal growth, each phosphorus molecule promotes the incorporation of 7

molecules of nitrogen and 40 molecules of carbon dioxide in aquatic algae.

Oil &grease: -

Oil and grease were not reported in the effluent sample of sugar industry for the three crushing seasons studied. Oil and grease are used for smooth operations of mill and other parts. Its value is high when the operation is defective.

Heavy Metals: Zinc, Mercury and Arsenic (Zn, Hg and As)

The amount of Zinc (Zn) in the effluents was found 6.0-7.5 mg/l during 2009-2010 and 5.0-8.0 mg/l during 2010-2011 and 2.5-6.0 mg/l during 2011-2012.The maximum value of Zinc 8 mg/l was recorded in May 2011& minimum 2.5 mg/l was found in Nov 2011. (Table No. 2 & 3).

Whereas Mercury (Hg) in the effluent was found nil and Arsenic (As) in the effluents was 0.013- 0.024 mg/l during 2009-2010 and 0.015-0.040 mg/l during 2010-2011 and 0.01-0.024 mg/l during 2011-2012.The maximum value of Arsenic 0.040 mg/l was recorded in May 2011 & minimum 0.013 mg/l was found in Nov 2009.(Table No.2 & 1). Ajmal *et.al*, (1985) recorded that the heavy metal concentrations in the water depend on the pH of the system. Metzner (1977) studied fate of copper and zinc at different pH in waste waters and found that solubility of these metals was inversely proportional to the system and higher solubility found at pH 7 or below.

After analysis of physico-chemical parameters of effluent samples from discharge point, it has been studied that most of parameters were very higher than their MPL, some were within tolerance limit. The discharge of these effluents flow into the river can raise pollution level of water. This water cannot be used for drinking purpose and cause serious health problems to aquatic biota as well as human and livestock.

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Removal of As(V) and Hg(II) ions from simulated wastewater using natural and modified Ca - bentonite

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Abstract— *Using natural and modified Ca-bentonite as an adsorbent to observe a satisfactory trend in the removal of heavy metal ions As(V) and Hg(II) from simulated wastewaters. In this original scientific paper, Ca-bentonite was modified in two ways, thermally activated at a temperature of 300 °C for 3 hours and acid activated with HCl and H_2SO_4, molar concentrations 0,4 mol/L. Ca-bentonite used in this original scientific work was used from the Shipovo mine (Šipovo mine), Bosnia and Herzegovina and proved to be an excellent bioadsorbent for the removal of present ions from simulated wastewaters. Also this is eco-friendly adsorbent and low costed compared to other expensive adsorbents. Due to its chemical composition in which two oxides predominate, namely SiO_2 (48.28 mass %) and Al_2O_3 (23.04 mass%), it can be concluded that Ca-bentonite from the Shipovo mine (Šipovo mine), Bosnia and Herzegovina belongs to the group of refractory materials. The highest removal efficiency of As(V) ions expressed in % was 75.11 at the initial concentration of 1.5 mg/L and was recorded using HCl acid-activated Ca-bentonite. The efficiency of Hg(II) ion removal was the highest using thermally activated Ca-bentonite and this value was 99.66% at an initial concentration of 1 mg/L.*

Keywords— ***Ca-bentonite, eco-friendly adsorbent, heavy metals, removal, wastewater***

I. INTRODUCTION

Environmental pollution by heavy metals has raised considerable attention due to their toxic impacts on plants, animals and human beings [1]. These pollutants affect all groups of organisms and ecosystem processes, including microbial activities [2]. Living systems most often interact with a cocktail of heavy metals in the environment [3]. Heavy metals are natural constituents of the environment, but indiscriminate use for human purposes has altered their geochemical cycles and biochemical balance [4]. The biggest increase is the pollution of the environment with wastewater from industry, which results in a reduction of drinking water for humans and animals [5]. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and

bioaccumulative nature [6]. These inorganic pollutants are being discarded in our waters, soils and into the atmosphere due to the rapidly growing agriculture and metal industries, improper waste disposal, fertilizers and pesticides [7]. Heavy metal pollution has become a growing concern today and poses a serious threat to humans and animals [8]. Metals tend to accumulate in water and move up through the food chain [9]. The toxicity of heavy metals mainly depends on their relative oxidation state, which is responsible for physiological biotoxic effects. When these metals enter living organisms, they, in combination with proteins, enzymes and DNA molecules, form highly stable biotoxic compounds, thus altering their proper functioning and interfering with their bioreactions [10]. They are classified as trace elements because of their presence in trace concentrations in various environmental matrices [11a]. Major contaminating sources of As(V) are herbicides, cattle and sheep dips and insecticides. Also as a desiccant for cotton crop to facilitate the mechanical harvesting of the crop. The availability of Hg(II) in wastewater comes from based funcides, sewerge sludge and atmospheric fall out resulting from combustion of fossil fuels and industrial processes [11b]. With the development of researches, the treatments of wastewater have reached a certain level. Whereas, heavy metals in wastewater cause special concern in recent times due to their recalcitrance and persistence in the environment [12].

Thus, the main strategies of pollution control are to reduce the bioavailability, mobility, and toxicity of metals [13]. Today, there are many conventional methods for removing heavy metal ions from wastewater. Removal of heavy metals from industrial wastewaters can be accomplished through various treatment options, including such unit operations as chemical precipitation, coagulation, complexation, adsorption, ion exchange, solvent extraction, foam flotation, electro-deposition, cementation, and membrane operations [14]. Common methods for removing heavy metals have numerous drawbacks, including low efficiency, high costs, limited capacity and difficulties in spontaneously removing multiple heavy metals [15].

Adsorption is a process in which pollutants are adsorbed on the solid surface [16]. Due to the high uptake capacity and very cost-effective source of the raw material, sorption is a progression towards a perspective method [17]. Bentonite is absorbent aluminium phyllosilicate clay [18]. The relatively low cost and wide versatility of reactive barriers favour the use of bentonite as an important component in barrier systems [19]. Removal of heavy metal ions using bentonite is a profitable technique because the material is available, cheap compared to activated carbon and some other expensive adsorbents [20]. Apkomie and Dawodua, 2015 reported that using bentonite it is possible to remove Ni(II) and Mn(II) ions from aqueous solutions above 90% [21].

II. METHODS

Determination of the basic composition of Ca-bentonite by X-ray fluorescence

X-ray fluorescence was used to determine the elemental composition of natural Ca-bentonite, which is a standard method according to BAS EN 15309:2010. This method is used to determine the following elements: Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Br , Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, Sn, Sb, Te, I, Cs, Ba, Ta, W, Hg, Tl, Pb, Bi, Th and U. The accuracy of the method depends from the type of instrument and the element that is determined and ranges from 0.0001% to 100%.

Determination of heavy metal content in Ca-bentonite

The standard method (ISO 11047:1998, IDT) QMS-UP-68 was used to determine the content of heavy metal ions in Ca-bentonite.

Determination of pH of Ca-bentonite

The pH value of Ca-bentonite was determined by the standard method, (ISO 10390:2005, IDT), QMS-UP-66.

Determining the point of zero charge

The pH value of the point of zero charge represents the state of the surface of the material when the sum of the negative charges is equal to the sum of the positive charges. This quantity is determined based on the change in the pH solution of the corresponding electrolyte under the influence of the adsorbent.

$NaNO_3$ concentration 0.1 mol/L, volume 50 mL was used as the basic electrolyte, which adjusted the pH value in the interval from 2-10 by adding HNO_3 or NaOH (0.01/0.1 mol/L). The initial pH value was measured and labeled as pHi. After that, Ca-bentonite was added and the suspension was left to stand for 24 hours with occasional stirring, the pH value was measured and marked as pHf. Based on the measured values, the diagram pHf = f(pHi) is created.

Thermal activation of Ca-bentonite

Thermal activation of Ca-bentonite was carried out by heating 25 grams of natural Ca-bentonite at a temperature of 300 °C for three hours. As a result of annealing, thermally activated Ca-bentonite was obtained, which was used as an adsorbent for the removal of As(V) and Hg(II) ions from simulated wasterwater.

Acid activation of Ca-bentonite

Acidic activation of Ca-bentonite was performed using two acids, namely HCl and H_2SO_4, which are in molar concentrations of 0.4 mol/L. The acid activation process was carefully carried out by gradually adding HCl acid in a total volume of 400 mL to 30 g of natural Ca-bentonite and mixing was carried out for the next 8 hours at 200 rpm. After that, the sample was filtered, dried at a temperature of 105 °C and sieved through a sieve with a diameter of 75 μm. The same procedure was done with H_2SO_4 acid. This acid-activated Ca-bentonite with HCl and H_2SO_4 was used as an adsorbent for the removal of As(V) and Hg(II) ions from simulated wasterwater.

Preparation of synthetic solutions of heavy metal ions

Synthetic aqueous solutions of As(V) is prepared from the atomic absorption standard (AAS) of 1000 μg/mL in 1mol/L HNO_3. It is produced from a very pure metal or salt (at least 99.99%) and tested with an ISO 17025 accredited test method (INAB Ref: 264T). Synthetic aqueous solutions of Hg(II) is prepared also from the atomic absorption standard (AAS) of 1000 μg/mL in 1 mol/L of HNO_3. *Table 1.* shows the initial concentrations (mg/L) of As(V) and Hg(II) ions which simulating wastewater.

Table 1. Initial concentrations of heavy metals

Metals	(mg/L)	(mg/L)	(mg/L)	(mg/L)
As(V)	0,5	1	1,5	2
Hg(II)	0,5	1	1,5	2

Heavy metal ions adsorption process

The process of adsorption of heavy metal ions As(V) and Hg(II) from aqueous solutions in this original scientific work was carried out using the following pre-prepared adsorbents:

1. natural (raw) Ca-bentonite,
2. thermally activated Ca-bentonite,
3. acid-activated Ca-bentonite with 0.4 mol/L HCl,
4. acid-activated Ca-bentonite with 0.4 mol/L H_2SO_4.

A mass of 1 g of natural Ca-bentonite was weighed on an analytical balance, which was then added to Erlenmayer flasks of 250 mL containing prepared stock solutions of heavy metal ions As(V) and Hg(II) in different concentration intervals that were prepared in advance. The Erlenmayer flasks were placed under continuous stirring for six hours at room temperature and a speed of 125 rpm. After the sample mixing process, slow filtration was performed through blue filter paper. In the resulting filtrate, the residual concentration of As(V) and Hg(II) was then determined by atomic absorption spectrophotometry. The same process of adsorption of heavy metal ions As(V) and Hg(II) from aqueous solutions was repeated for all four aforementioned adsorbents.

Determination of heavy metal content by atomic absorption spectrophotometry

The residual concentration of heavy metal ions As(V) and Hg(II) expressed in mg/L after the adsorption process was determined using an atomic absorption spectrophotometer, 240 Series Agilent Technology.The mathematical equation that was used to calculate the percentage efficiency of removal of heavy metal ions in wastewater is:

$$\% = C_r - C_i/C_i$$

where is:

% - percentage efficiency of removal of heavy metal ions

C_i – initial concentarion of heavy metal ions (mg/L)

Cr – residual concentration of heavy metal ions (mg/L)

III. RESULTS AND DISCUSSION

Results of determination of the basic composition of natural (raw) Ca-bentonite by X-ray fluorescence

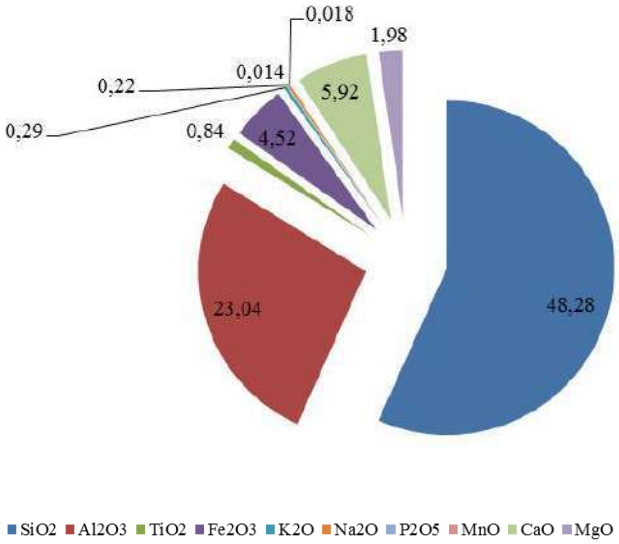

Fig.1. Chemical composition of analyzed natural Ca-bentonite by X-ray fluorescence expressed in mass percentage (mass %)

Based on *Figure 1.*, which shows the elemental composition of natural Ca-bentonite expressed in mass percentages %, it can be seen that the highest proportion of SiO_2 oxide is 48.28 mass % and Al_2O_3 oxide is 23.04 mass %. In addition to these two most abundant oxides, others were also recorded in smaller percentages, which is clearly visible in *Figure 1.*

Similar results were obtained by other scientists such as Abdullahi and Audu, 2015 who compared two samples of natural bentonite, and their results were as follows: 48.16% and 49.87% for SiO2, 14.86 and 14.98% for Al_2O_3 and Fe_2O_3, respectively: 4,80% and 5.12%. [22]. Further, comparing the SiO_2 oxide results with the results reported by Newke et al., 2008 (45 mass%) and Tabak et al., 2015 (48.35%) to conclude that it is a material that is a significant carrier of aluminosilicate [23], [24]. Based on these obtained results, it can be concluded that Ca-bentonite from the Shipovo mine (Šipovo mine), Bosnia and Herzegovina belongs to the group of refractory materials.

Results of determination of heavy metal content in natural Ca-bentonite

The content of heavy metals in the bentonite clay sample is showed in *Table 2.*

Table 2. Content of heavy metals in natural Ca-bentonite

Elements in Ca-bentonite	Metal concentration (mg/kg)	Limit values for clay soil (mg/kg)
Zn	2,61	200
Pb	31,41	100
Cd	0,56	1,5
Ni	4,08	50
Co	9,86	60
Fe	2224,83	50000
Mn	30,56	1000
Cu	10,79	80
Cr	0,77	100

Limit values of the content of tested metals in the soil are prescribed by the Rulebook on Determination of Harmful and Hazardous Substances in Soil and Methods of Their Testing "Official Gazette of the Federation of BiH", No. 72/09. The Ordinance sets limits for the content of heavy metals for different soil textures (sandy, powdery and clayey) and is expressed in mg/kg. Since Ca-bentonite belongs to the family of clay minerals, only the limit values for clay soil are presented in the paper (*Table 2.*). Comparing the content of tested heavy metals with the limit values, it is clear that the concentrations of heavy metals in Ca-bentonite do not exceed the prescribed limit values. Accordingly, this natural material is very suitable for use in the adsorption process [25a]

Results of determination of pH value of Ca-bentonite

The measured pH value of natural Ca bentonite was 8.86.

Results of determining the zero charge point

The zero charge point determined for Ca-bentonite is shown in the *Figure 2*. The value of the zero charge point represents the pH value above which cation removal will be favored. A value of 8.27 can be seen in the figure, ie above this value, the removal of positively charged ions will be more efficient. By comparing the obtained results, it obtained a slightly lower value in its work 7.8 for natural clay [25b].

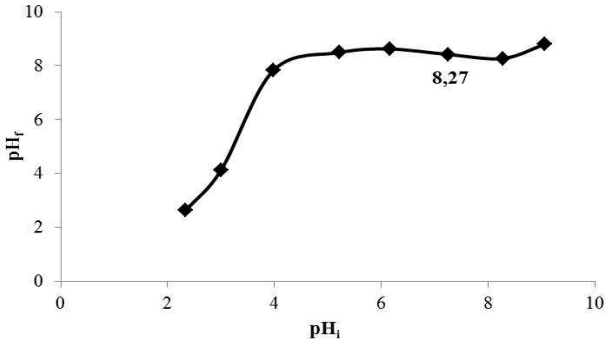

Fig.2. Zero charge point

Results of determining the optimal adsorption capacity

Removal As(V) and Hg(II) ions from simulated wastewater treated with natural Ca-bentonite

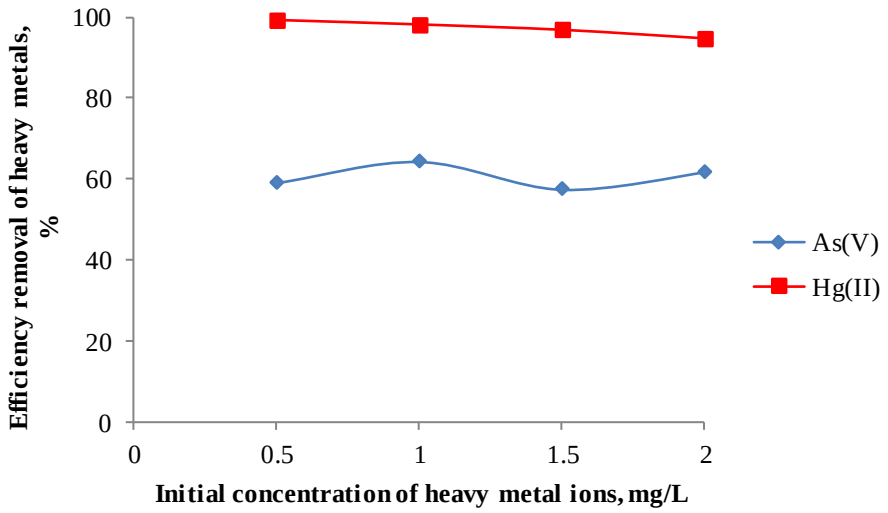

Fig.3. Removal efficiency of As(V) and Hg(II) ions from simulated wastewater treated with natural Ca-bentonite

Based on *Figure 3*., it can be clearly seen that the highest removal percentage of As(V) ions was at the initial concentration of this metal ion of 1 mg/L, and this removal percentage was 64.31%. However, the percentage of removal of Hg(II) ions was above 94% at all concentrations. The highest percentage of Hg(II) ion removal is observed at the lowest initial concentration of this metal ion. By increasing the initial concentration of the metal ion Hg(II), the percentage of removal also decreased. Accordingly, the lowest removal percentage was at the highest initial concentration and was 94.85%. Viraraghavan and Kapoor, 1994 reported that the percent removal of Hg(II) ions from wastewater with the application of Na-bentonite amounted to 34.2% [26]. Based on this, it can be concluded that Ca-bentonite showed a significantly higher adsorption capacity for the removal of Hg(II) ions compared to Na-bentonite, and that it is a high-quality adsorption material.

Removal As(V) and Hg(II) ions from simulated wastewater treated with thermally activated Ca-bentonite

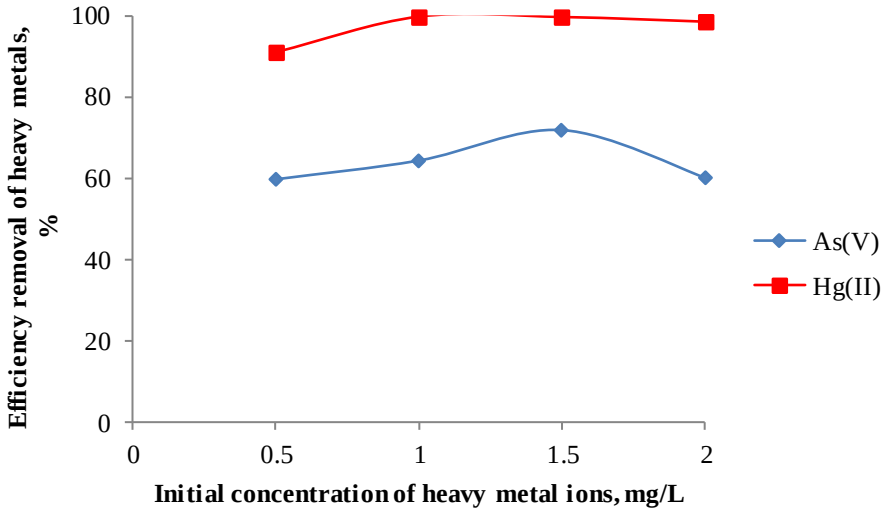

Fig.4. Removal efficiency of As(V) and Hg(II) ions from simulated wastewater treated with thermally activated Ca-bentonite

The removal efficiency of As(V) and Hg(II) ions using thermally activated Ca-bentonite had a similar removal curve as when using natural Ca-bentonite. The highest removal percentage of As(V) ions was 71.82% at the

initial concentration of 1.5 mg/L, and after this value, the removal percentage decreased. At the initial concentration of 0.5 mg/L, less Hg(II) ions were removed than when using natural Ca-bentonite. However, the highest percentage of Hg(II) ion removal was 99.66% at the initial concentration of 1 mg/L, which is a higher value compared to the application of natural Ca-bentonite. After that, the trend of decreasing removal percentage continued.

Removal As(V) and Hg(II) ions from simulated wastewater treated with H_2SO_4 activated Ca- bentonite

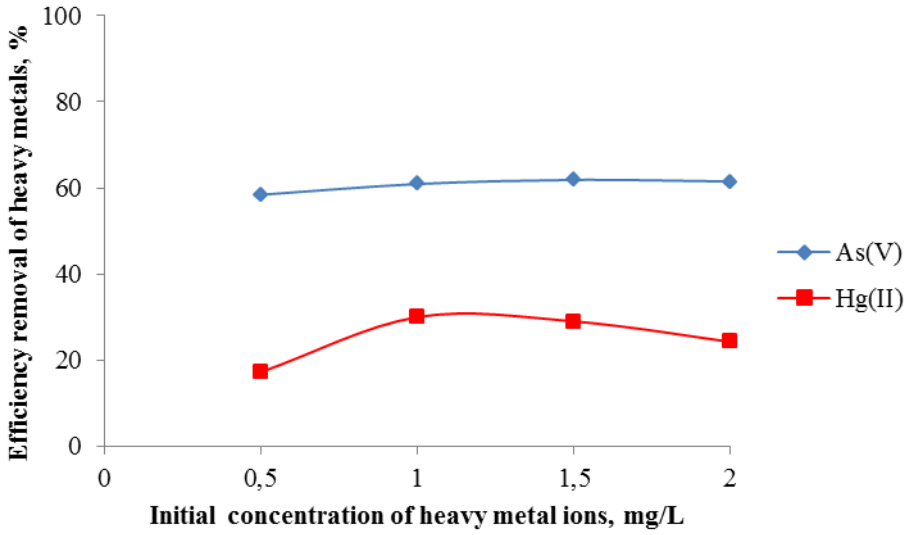

Fig.5. Removal efficiency of As(V) and Hg(II) ions from simulated wastewater treated with H_2SO_4 activated Ca- bentonite

As can be seen from *Figure 5*., the percentage of removal of As(V) ions is higher in relation to Hg(II) ions using Ca-bentonite activated with H_2SO_4 compared to the removal using natural Ca-bentonite and thermally activated Ca-bentonite. The highest percentage of removal of Hg(II) ions was 30 mg/L at an initial concentration of 1 mg/L, while with further increase of the initial concentration, a trend of decreasing percentage of removal of these ions was observed. The percentage removal of As(V) ions had similar values to the percentage removal of these ions using natural Ca-bentonite and thermally activated Ca-bentonite. As with Hg(II) and As(V), a trend of increased removal percentage was observed and the highest value was recorded at an initial concentration of 1.5 mg/L and was 61.75%, while already at an initial concentration of 2 mg /L observed a decrease in the removal percentage of these ions.

Removal As(V) and Hg(II) ions from simulated wastewater treated with HCl activated Ca-bentonite

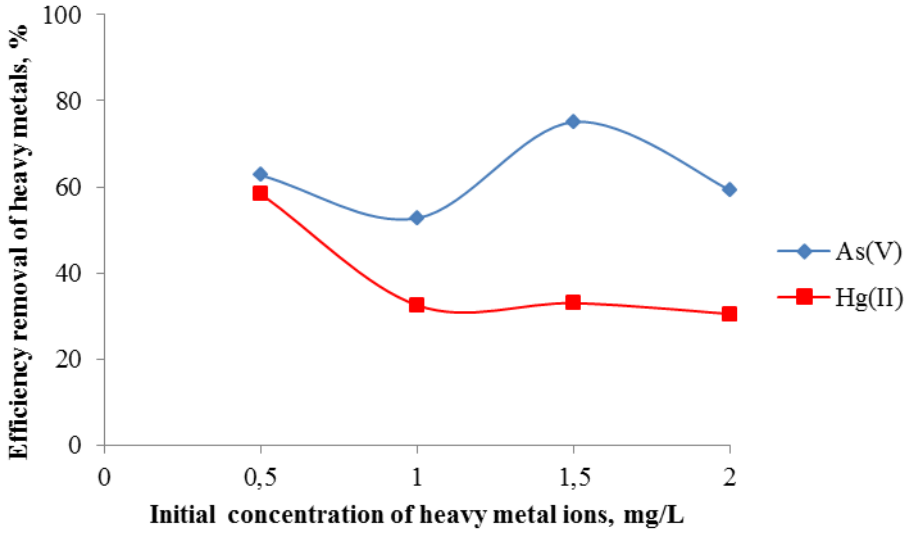

Fig.6. Removal efficiency of As(V) and Hg(II) ions from simulated wastewater treated with HCl activated Ca- bentonite

The removal efficiency of As(V) ions using Ca-bentonite activated with HCl was 75.11% at an initial concentration of 1.5 mg/L, and this is the highest recorded value in relation to the adsorption procedures used so far. A slightly lower percentage of removal was recorded using Ca-bentonite activated with H_2SO_4. From this it can be concluded that Ca-bentonite activated with HCl is the best choice compared to natural, thermally and acid-activated Ca-bentonite with H_2SO_4 for removal of As(V) ions from simulated wastewater. Application of acid activated Ca-bentonite with HCl and H_2SO_4 in both cases better removal of As(V) ions compared to Hg(II) ions. The highest percentage of removal of Hg(II) ions was 58.40% at the initial concentration of 0.5 mg/L, while with further increase of the initial concentration, a constant trend of decreasing percentage of removal of these ions was observed.

Values of Freundlich constants

Table 4. Values of Freundlich constants

Metal ions	Adsorbens	Kf	1/n	R^2
As(V)	NB	10	1	1
	TAB	10	1,0001	1
	ABh	10	0,9995	1
	ABs	10	1	1
Hg(II)	NB	10	1	1
	TAB	10	1	1
	ABh	10	-	1
	ABs	10	-	1

Legend: NB – natural (raw) bentonite; TAB – thermal activated bentonite; ABh – acid activated bentonite with HCl; ABs – acid activated bentonite with H_2SO_4

Based on the data on the Freundlich isotherm values given in the table, it can be concluded that the coefficient 1/n for all used biosorbents is less than one, which indicates that it is a large heterogeneous surface of the used sorbents, i.e. that there are sorption centers with high energy that show good sorption intensity according to the investigated heavy metal ions. The exception is TAB for the adsorption of As(V) ions, where this value is slightly higher than 1. The values of the Kf constant for all used biosorbents were around 10. For all analyzed biosorbents, the correlation factor (R^2) was 1, which additionally confirmed that the obtained values is best described by the Freundlich adsorption isotherm model. The isotherm for the adsorption of the heavy metal ions on bentonite clay was confirmed by the Freundlich isotherm which offered good consequences. The results indicated that bentonite was utilized as an efficient ion exchange element for the removal of heavy metal ions from polluted water [27].

IV. CONCLUSION

Based on the conducted experiment, it can be concluded that modified, ie thermally activated and HCl and H_2SO_4 acid-activated Ca-bentonite gives better results in removing As(V) and Hg(II) ions compared to natural (raw) Ca-bentonite. Natural Ca-bentonite also had an enviable removal percentage of Hg(II) ions and this value was above 94% for all initial concentrations of this metal ion. However, a slightly higher percentage was nevertheless thermally activated by the application of Ca-bentonite. Also, a solid percentage of As(V) ion removal was recorded using natural Ca-bentonite, however, the best result was HCl acid-activated Ca-bentonite, whose removal percentage was 75.11%. Based on the obtained experimental results, it can be concluded that Ca-bentonite was used from the area of Šipovo, Bosnia and Herzegovina can be used to remove heavy metal ions.

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Cardiopulmonary function, quality of life, musculoskeletal pain and serum lead level of welders in Enugu, Nigeria

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Abstract— *The study related serum lead level to cardiopulmonary function, quality of life and musculoskeletal pain of welders in Enugu, Nigeria. Snowball sampling technique was adopted to reach over 100 Enugu resident welders. The first 100 who met the inclusion criteria and gave their consent to participate in the study were sampled. The welders' serum lead level was 0.522µg/dl (0.06-1.26 µg/dl). The welders had prevalent low back pain and a very high quality of life for the domain of physical health with a score of 94, and high psychosocial and social relationship domains for quality of life with the scores of 69 and 75 respectively. About 64.2% of the welders had an elevated systolic blood pressure above 120mmHg and 52.6% had diastolic blood pressure elevated above 80mmHg, while only 3.2% of the welders had pulse rates above 100 beats per minute. The mean values for lung function were FVC = 1.43, FEV1 = 1.13 and PEF = 1.61. The significant relationship between serum lead levels (FVC, FEV1 and PEF) could be attributed to lead inhalation. The significant relationship between serum lead levels and low back pain and knee pain could be attributed to lead's effect on the musculoskeletal system.*

Keywords— ***cardiopulmonary function, quality of life, musculoskeletal pain, serum lead level, welders.***

I. INTRODUCTION

Welding is a very important process used for joining metal. With the quick development of science and industry, welding is used in more production fields, and the number of welders is increasing. Welders are exposed to many occupational hazards, including welding fumes, leading to serious occupational health problem all over the world. Lead affects major organ system in the body including hematopoietic, gastrointestinal, respiratory, renal, nervous and cardiovascular mainly through

increased oxidative stress, ionic mechanism and apoptosis (Qin, Liu, Zhu, Weng, Xu, Ai 2014; Balkhour, Goknil 2010). Welders are also exposed to dust; heavy metals like lead; gases like fluoride, nitrogen, carbon monoxide; noise; and ultraviolet rays. Lead poisoning could cause hearing impairment, joint and muscles pains (Antonini, Santamaria, Jenkins, Albini, Lucchini 2006).

Musculoskeletal pain affects the muscles, ligaments, tendons, and nerves. It can be acute or chronic, it can be localized or widespread. Lower pain is the most common type of pain. Others are tendinitis, myalgia (muscle pain), and stress fractures. Musculoskeletal pain can also be caused by overuse. Pain from overuse affects 33% of adults. Lower back pain is the most common work-related diagnosis (Cleveland Clinic Foundation 2014).

A worker begins to fatigue when exposed to musculoskeletal pain risk factors. If the fatigue outruns the body recovery system, musculoskeletal disorder develops. Work related (ergonomic) risk factors, like high task repetition, can result in musculoskeletal risk factor. When combined with other risk factors, such as high force and/or awkward postures, high task repetition can contribute to the formation of musculoskeletal pains. A job is highly repetitive if the cycle time is 30s or less. Forceful exertions have also been found to bring about musculoskeletal pain. Many work tasks require high force loads on human body and muscle efforts increases in response to high force requirement with associated fatigue which can lead to musculoskeletal pains. Similarly, awkward postures place excessive force on joints and overload the muscles and tendons and affected joints (Ergonomics Plus 2011).

Lead is a highly toxic metal and a very strong poison. Lead poisoning is a serious and sometimes fatal condition. It occurs when lead builds in the body. Lead toxicity is rare after a sin glee exposure or ingestion of lead. A high toxic dose of lead poisoning may result in emergency symptoms, muscle weakness, severe abdominal pain and cramping, seizures, encephalopathy which manifests as confusion, coma and seizures (Healthcare Newsletter 2010).

In 2003, lead reportedly led to 853,000 deaths mostly in developing countries, and poor people are at greater risk. Lead is believed to result in 0.6% of the world's disease burden. The amount of lead in the blood tissues, as well as the time course of exposure, determine toxicity (World Health Organization 2018; Pearson, Schonfeld 2005; Needleman 2004).

The U.S. Center for Disease Control and Prevention and the WHO state that a serum lead level of 10µg\dL or above is a cause for concern. However, lead may impair development and have harmful health effects even at lower levels, and there is no known safe exposure level (Rossi 2000; Barbosa, Trans-Santos, Gerlach, Parsons 2005). The effects of metals, like lead (Pb), iron (Fe), manganese (Mn), zinc (Zn), Titanium, among others, showed significant adverse health effects, such as pulmonary inflammation, granulomas, fibrosis, genotoxicity, after inhalation (Michelle, Alexandra, Marco, Giancarlo 2012). Exposure routes of lead show that it is a common environmental pollutant. They include environmental industrial uses of lead, such as processing of lead-acid batteries or production of lead wire or pipes and metal recycling; processing of lead containing products, such as food and paints; soil and water containing lead (Manay, Cousillas, Alvarez, Heller 2004).

Cardiopulmonary function is the interrelation between the working of the heart and lung organs. The most important function of the cardiopulmonary system has to do with the flow and regulation of blood between the heart and the lungs, made through the pulmonary artery. The cardiovascular system is the method by which the heart and the entire network of blood vessels function together to direct the flow of blood throughout the body. The cardiorespiratory system describes the function of the heart in relations to the body's entire breathing mechanism, from the nose and the throat to the lungs. These three systems function interdependently. Consequently, the efficiency of heart function will depend on the strength of the heart muscle. Aerobic exercise makes the heart stronger and better equipped to propel blood. The power of the heart and clear unobstructed pulmonary artery passages performing in concert permit the efficient movement of blood to and from the lungs, where useful oxygen and waste carbon dioxide are exchanged in microscopic lining compartment known as alveoli. Chronic and acute lead poisoning cause overt, clinical symptoms of cardiac and vascular damage with potentially lethal consequences. Morphological, biochemical and functional derangement of the heart have all been described in patients following exposure to excessive lead levels. It is clear the lead toxicity affects the quality of life of individuals exposed to level of lead poisoning leading to some severe health conditions (Kopp, Barron, Tow 1988).

According to Occupational Safety and Health Administration (Occupational Safety and Health Administration 1999), work-related musculoskeletal pains currently account for one-third of all occupational injuries/illnesses reported to the Bureau of Labour Statistics (BLS) and are the largest job-related injury and illness problem in the United States today. Workers with severe musculoskeletal pains can face permanent disability which not only affects work activities but also can prevent the performance of everyday activities thereby posing

treats to the quality of life of the individual. Hamburg Construction worker study found that of the subjects having a lower back disorder 60.4% had a reduction of mobility 27% had paravertebral muscle spasms, 24.4% had pain during movement and 10.7% had signs of sciatic nerve compression (Sturner, Luessenhoop, Net, Soyka, Karmaus, Tousaint, Liebs, Relder 1997). With the surge in the increased in the day to day activities, with little or no knowledge about the dangers welders are exposed such as lead toxicity which in one way or the other poses treat to health or quality of life of these group of workers in the areas of musculoskeletal systems, cardiopulmonary functions and their generalwellbeing. These heavy metals give cumulative deteriorating effects that can cause chronic degenerative changes (Ibrahim, Frobery, Wolf, Rusynick 2006), especially to the nervous system, liver and kidneys and in some cases, they also have teratogenic and carcinogenic effects (International Agency for Research on Cancer 2006).

There is paucity of studies on the topic in Nigeria especially South-Eastern Nigeria. This study aimed to relate the serum lead level to cardiopulmonary functions, quality of life and musculoskeletal pains of welders in Enugu, Nigeria by seeking the answers to the following questions:

1. What is the serum level of lead among welders in Enugu metropolis?
2. What is the prevalence of pains among welders in Enugu metropolis?
3. What is quality of life of welders in Enugu metropolis?
4. What is the cardiopulmonary functions of welders in Enugu metropolis?
5. What is the relationship between cardiopulmonary functions, quality of life, musculoskeletal pains and serum levels of lead among welders in Enugu Metropolis?
6. What is the relationship between the length of exposure, age, and serum lead level?

The specific objectives were to:

1. Determine the serum level of lead among welders in Enugu Metropolis.
2. Ascertain the prevalence of pains among welders in Enugu metropolis.
3. Ascertain the quality of life of welders in Enugu metropolis.
4. Ascertain the cardiopulmonary functions of welders in Enugu metropolis.
5. Ascertain the relationship between cardiopulmonary functions, quality of life, musculoskeletal pains and serum levels of lead among welders in Enugu Metropolis
6. Ascertain the relationship between the length of exposure, age, and serum lead level.

The hypotheses that guided the study were:

1. There is no significant relationship between musculoskeletal pains, quality of life, cardiopulmonary function and serum level of lead among welders in Enugu Metropolis.
2. There is no significant relationship between the length of exposure, age, and serum level of lead.

The findings of this study will enlighten the welders and the general public on the health status of welders in Enugu Metropolis. They will also guide physiotherapists and other health professionals on the need for holistic assessment of welders especially on quality of life and cardiopulmonary functions, and health workers on public health enlightenment on the risk of exposure to lead, especially among welders. This study will also serve a reference to point for future research in similar areas of study on exposure to lead toxicity.

II. MATERIALS AND METHODS

2.1 Design

The study utilized a cross-sectional research design. Convenience sampling technique was used based on the number of subjects present during the time of study who were willing to participate and met the inclusion criteria. A total of 100 welders participated in this study.

2.2 Inclusion and exclusion criteria

The selection criteria were inclusion and exclusion criteria. Only welders in Enugu metropolis from 18 years and above who had worked at least six (6) months were included in this study. Subjects excluded were those suffering from trauma, fracture, arthritis, neurological conditions, hypertension, cardiac problems and respiratory diseases such as asthma.

2.3 Informed consent

The study procedure was explained to the prospective subjects, from whom informed consent for participation in the study and allowing academic publication/s of the results of the study with anonymity were sought and obtained.

2.4 Ethical Committee approval

The Health Research and Ethical Review Committee of the University of Nigeria Teaching Hospital (UNTH)

Ituku-Ozalla, Enugu, which covers the area of study in the Primary Healthcare Programme of the Federal Government of Nigeria (FGN), gave the ethical approval for the study. All methods were performed in accordance with the relevant guidelines and regulations.

2.5 Samples collection

A World Health Organization (WHO) Quality of Life questionnaire, Nordic questionnaire for pain, stadiometer for measuring height, bathroom weighing scale (Hana Model calibrated in kilogram) for weight measurement, sphygmomanometer (Omrion China) for measuring the blood pressure of both the systolic and diastolic, needle and syringe for drawing blood samples, and cotton wool and methylated spirit were used. WHO questionnaire consists of 26 questions which were explained to the subject in case of any confusion or difficulty. Nordic questionnaire consists of demographic part and other sections like pain intensity rating scale, anthropometric part, and the part for treatment intervention. The completed questionnaire instrument was retrieved. The two questionnaires were either self-administered by the subjects or administered by the researchers.

To obtain the height of the participant, the improvised stadiometer calibrated in centimeter was placed on flat surface and the subject was asked to remove the footwears and stand in the platform on the stadiometer in an upright position with the heels in contact with the vertical bar of the stadiometer for the reading which was recorded. To obtain the weight, the participant was asked to step on a weighing scale with bare foot, stand erect and look straight at an eye level for a reading which was taken. To obtain the cardiovascular parameters, the subject was asked to stay quiet, calm and rest for five (5) minutes and an automatic sphygmomanometer was used to obtain the systolic and diastolic blood pressure as well as the pulse rate. The cuff was placed around a bare arm 1-2 cm above the elbow joint. While seated, the palm was supinated in front on a flat surface (desk). The cuff was fitted comfortably, yet strongly around the left arm.

New and unused sterile needles, syringes and blood sample bottles, obtained from a tertiary health institution (Teaching Hospital) that sourced pharmaceuticals and medical equipment from reputable pharmaceutical manufacturing companies in Asia and South Africa, were assumed to lead-free and used by a phlebotomist (staff of the institution) to collect the blood samples, with swab cotton wool/methylated spirit. The phlebotomist gave a sample bottle to each subject to collect early morning urine and store it in the fridge between delivering it to the medical diagnostic laboratory unit of the institution, where a medical laboratory scientist analyzed the samples for serum levels of Pb (independent variables) and the pulmonary functions (dependent variables) of the welders. The two sets of data were subjected to regression to determine the relationship between the variables. The data were subjected to descriptive statistics and analysed using paired and unpaired sample t-test. Pearson correlation was used to determine the relationship between the variables. A probability value of 0.05 was considered statistically significant. Analysis was performed using Statistical Package for Social Sciences (SPSS) 20.0 for windows evaluation version.

2.6 Determination of serum lead level

Serum lead levels were determined by Environmental Protection Agency (EPA) of the United States of America (USA) Method – 200_13 – Trace element determination via Atomic Absorption Graphite Furnace Spectrometer using Buck Scientific Atomic Absorption Spectrophotometer (GFAAS, made in USA). Ni served as matrix modifier for Pb (Bakırdere *et al*, 2013).

III. RESULTS

Table 1 shows the siociodemographic characteristics of participants.

Table 1: Siociodemegraphic characteristics

Sociodemographics characteristics	Percent	Frequency
AGE		
18-24	26	27.4
25-34	39	41.1
35-44	20	21.1
45-64	10	10.5
EDUCATION QUALIFICATION		
Informal	2	2.1
Primary	24	25.3
OND	63	66.3
BSc	4	4.2
MSc	1	1.1
PhD		
MARITAL STATUS		
Single	57	60.0
Married	38	40.0
BMI		
Underweight	8	8.4
Normal	61	64.2

Overweight	20	21.1
Obese	6	6.3
DURATION OF WORK		
< 6 months	3	2.9
6-1yr	1	1.0
1-2yrs	16	15.2
2-3yrs	17	16.2
3-4yrs	1	1.0
4-5yrs	5	4.8
>5yrs	52	49.5

Twenty-six per cent (26%) of participants were aged 18-24. Thirty-nine per cent (39%) of participants were of age bracket 25-34. Twenty per cent (20%) of participants were aged 35-44. Ten per cent (10%) of participants were of age bracket 45-64.

Participants with informal education were 2%, primary education were 24%, OND were 63%, BSc were 4%, MSc was 1%, and PhD none (0%). About equal portion of participants were single (57%) and married (58%). Participants' body mass index values were underweight (8%), normal (61%), overweight (20%), and obese (6%). Work duration of participants were 6 months (3%), 6 months to 1 year (1%), 1-2 years (16%), 2-3 years (17%), 4-5 years (1%), and less than 5 years (52%).

Table 2 shows the prevalence of musculoskeletal pain.

Table 2: Prevalence of musculoskeletal pain

Region	12-month-prevalence		Hinderance		7-day prevalence	
	Frequency	Percent	Freqeuncy	percent	Frequency	Percent
NECK						
Yes	20	21.1	1	1.1	3	3.2
No	75	78.9	94	98.9	92	96.8
SHOULDER						
Yes	19	18.1	2	2.1	2	2.1
No	76	80.0	93	97.9	93	97.9
UPPER BACK						
Yes	15	14.3	4	4.2	91	95.8
No	80	4.2	91	95.8	1	1.1
ELBOW						
Yes	12	12.6	4	4.2	1	1.1
No	83	87.4	91	95.8	94	98.9
WRIST						
Yes	15	16.0	5	5.3	4	4.2
No	79	84.0	90	94.7	91	95.8
LOWER BACK						
Yes	61	64.2	15	15.8	NR	NR
No	34	35.8	80	84.2	NR	NR
HIP						
Yes	17	17.9	2	2.1	2	2.1
No	78	82.1	93	97.9	93	97.9
KNEE						
Yes	23	21.9	5	5.3	9	9.5
No	72	75.8	90	94.7	86	90.5
ANKLE						
Yes	16	16.8	4	4.2	3	3.2
No	79	83.2	90	94.7	91	95.8

About 21.1% had neck pain which prevailed for 7 days for 3.2% of participants. About 75% did not have it and it did not prevail for 7 days in 96.8% of participants.

Almost 19% had pain in the shoulder which prevailed for 7 days for 2.1% of participants. Almost 76% did not have it and it did not prevail for 7 days 96.8% of participants.

About 15% had upper-back pain which prevailed for 7 days for 14.3% of participants. About 80% did not have it and it did not prevail for 7 days 95.8% of participants.

Nearly 12% had elbow pain which prevailed for 7 days for 12.6% of participants. Nearly 83% did not have it and it did not prevail for 7 days 98.9% of participants.

Almost 15% had wrist pain which prevailed for 7 days for 4.2% of participants. Almost 79% did not have it and it did not prevail for 7 days 95.8% of participants.

Sixty-one per cent (61%) of participants had lower-back pain, while 34% did not have it. About 17% had hip pain which prevailed for 7 days for 2.1% of participants. About 78% did not have it and it did not prevail for 7 days 97.9% of participants.

Almost 23% had knee pain which prevailed for 7 days for 9.5% of participants. Almost 72% did not have it and it did not prevail for 7 days 90.5% of participants.

About 16% had ankle pain which prevailed for 7 days for 3.2% of participants. About 79% did not have it and it did not prevail for 7 days 95.8% of participants.

Table 3 shows the classification of participants by pain intensity.

Table 3: Classification of participants by pain intensity

	PAIN INTENSITY							
REGION	no pain		mild		moderate		severe	
	fre	per	fre	per	fre	per	fre	per
NECK	71	74.7	13	13.7	8	8.4	3	3.2
SHOULDER								
Right	71	74.7	14	14.7	7	7.4	3	3.2
Left	71	74.7	15	15.8	5	5.3	4	4.2
Upper back	71	74.7	10	10.5	10	10.5	4	4.2
ELBOW								
Right	80	84.2	9	9.5	5	5.3	1	1.1
Left	78	82.1	10	10.5	5	5.3	2	2.1
WRIST								
Right	75	79.8	12	12.8	6	6.4	1	1.1
Left	76	80.0	13	13.7	3	3.2	3	3.2
Lower back	30	31.9	19	20.2	29	30.9	16	17.0
HIP								
Right	76	80.0	11	11.6	6	6.3	2	2.1
Left	75	78.9	12	12.6	5	5.3	3	3.2
KNEE								
Right	69	72.6	11	11.6	11	11.6	4	4.2
Left	67	70.5	14	14.7	10	10.5	4	4.2
ANKLE								
Right	76	80.0	10	10.5	6	6.3	3	3.2
Left	74	77.0	11	11.6	7	7.4	3	3.2

Almost 74.7% of participants had no neck pain, 13.7% had mild, 8.4% had moderate, and 3.2% had severe neck pain. Almost 74.7% of participants no shoulder pain. About 14.7% had mild right shoulder pain. Almost 7.4% had moderate right shoulder pain. Almost 3.2% had severe right shoulder pain.

About 74.7% of participants had no left shoulder pain. About 15.8% had mild left shoulder pain. About 5.3% had moderate left shoulder pain. About 4.2% had severe left shoulder pain. Almost 74.7% of participants had no shoulder upper-back pain. Almost 15.8% had mild shoulder upper-back pain. Almost 5.3% had moderate shoulder upper-back pain. Almost 4.2% had severe shoulder upper-back pain.

About 84.2% of participants had no elbow right pain. About 9.5% had mild elbow right pain. About 9.5% had moderate elbow right pain. About 5.3% had severe elbow right pain. Almost 82.1% of participants had no elbow left pain. Almost 10.5% had mild elbow left pain. Almost 5.3% had moderate elbow left pain. Almost 2.1% had severe elbow left pain.

About 79.8% of participants had no wrist right pain. About 12.8% had mild wrist right pain. About 6.4% had moderate wrist right pain. About 1.1% had severe wrist right pain. Almost 80.0% of participants had no wrist left pain. Almost 13.7% had mild wrist left pain. Almost 3.2% had moderate wrist left pain. Almost 3.12% had severe wrist left pain. About 31.9% of participants had no lower-back wrist pain. About 20.2% had mild wrist lower-back pain. About 30.9% had moderate wrist lower-back pain. About 17.0% had severe wrist lower-back pain.

Almost 31.9% of participants had no right hip pain. Almost 11.6% had mild right hip pain. Almost 6.3% had moderate right hip pain. Almost 2.1% had severe right hip pain. About 78.9% of participants had no left hip pain. About 12.6% had mild left hip pain. About 5.2% had moderate left hip pain. About 3.2% had severe left hip pain.

Almost 72.6% of participants had no right knee pain. Almost 11.6% had mild right knee pain. Almost 11.6% had moderate right knee pain. Almost 4.2% had severe right knee pain. About 70.5% of participants had no left knee pain. About 4.7% had mild left knee pain. About 10.5% had moderate left knee pain. About 4.2% had severe left knee pain.

Almost 80.0% of participants had no right ankle pain. Almost 10.5% had mild right ankle pain. Almost 6.3% had moderate right ankle pain. Almost 3.2% had severe right ankle pain. About 77.0% of participants had no left ankle pain. About 11.6% had mild left ankle pain. About 7.4% had moderate left ankle pain. About 3.2% had severe left ankle pain.

Table 4: Serum lead, cardiopulmonary functions and quality of life of participants.

Table 4: Serum lead, cardiopulmonary functions and quality of life of participants

Variables	Mean	Standard Deviation
Lead serum L	5.22	.30297
SBP	124.53	14.57
DBP	81.4737	13.36
PR	77.64	12.91
FVC	1.43	0.88
FEV1	1.13	0.65
PEF	1.61	1.16
Physical	14.00	1.48
Psychological	14.17	1.83
Social relation	15.50	2.74
Environment	12.12	1.81
Overall quality of life (QOL)	55.93	5.77

Mean serum lead level was 5,22±0.30297. Mean SBP was 124.53±14.57. Mean DBP was 81.4737±13.36. Mean PR was 77.64±12.91. Mean FVC was 1.43±0.88. Mean FEV1 was 1.13±0.65. Mean PEF was 1.61±1.16. Mean physical was 14.00±1.48. Mean psychological was 14.17±1.83. Mean social relation was 15.50±2.74. Mean environment was 12.12±1.81. Mean overall QOL was 55.93±5.77. Notably, serum lead level is related to FVC at p-value of .003, to FEVI at p-value of .002 and to PEF at p-value of .020.

Table 5 shows the relationship among serum lead level, cardiopulmonary function and quality of life.

Table 5: Relationship among serum lead level, cardiopulmonary function and quality of life

Variables	Lead serum level	
	Co-relation (R)	p-value
Physical	-.049	.637
Psychological	.138	.181
Social relationship	.131	.205
Environment	.138	.182
Overall QOL	.149	.148
FVC	.298	.003*
FEVI	.309	.002*
PEF	.239	.020*

The co-relation value (R) was -.049 and probability value (p-value) was .637 for physical. R was .138 and p-value was .181 for psychological. R was .131 and p-value was .205 for social relationship. R was .138 and p-value was .181 for environment. R was .149 and p-value was .148 for overall QOL. R was .298 and p-value was 0.003* for FVC. R was .309 and p-value was .002* for FEVI. R was .239 and p-value was .020* for PEF.

Table 6 shows the association between serum lead level and self-reported prevalence of musculoskeletal pain.

Table 6: Association between serum lead level and self-reported prevalence of musculoskeletal pain

	lead category			
	accept	above accept	Chi-square	p-value
NECK PAIN – 12 MONTHS				
Yes	3	17	0.290	0.590
No	8	67		
NECK HINDERANCE				
Yes	-	1	0.132	0.716
No	11	83		
NECK PAIN – 7 DAYS				
Yes	-	3	0.406	0.524
No	11	81		
SHOULDER PAIN – 12 MONTHS				
Yes	2	17	0.026	0. 873
No	9	67		
SHOULDER HINDERANCE				
Yes	-	2	0.268	0.605
No	11	82		
SHOULDER PAIN – 7 DAYS				
Yes	-	2	0.268	0.605
No	11	82		
UPPER BACK – 12 MONTHS				
Yes	-	15	2.333	1.27

No	11	69		
UPPER BACK HINDERANCE				
Yes	-	4	0.547	0.460
No	11	80		
UPPER BACK – 7 DAYS				
Yes	-	3	0.547	0.761
No	11	80		
ELBOW PAIN – 12 MONTHS				
Yes	-	12	1.799	0.180
No	11	72		
ELBOW HINDERANCE				
Yes	-	4	0.547	0.460
No	11	80		
ELBOW PAIN – 7 DAYS				
Yes	-	1	0.132	0.716
No	11	83		
WRIST PAIN – 12 MONTHS				
Yes	-	15	2.365	0.124
No	11	68		
WRIST HINDERANCE				
Yes	-	5	0.691	0.406
No	11	79		
WRIST PAINS – 7 DAYS				
Yes	-	4	0.547	0.460
No	11	80		
LOWER BACK – 12 MONTHS				
Yes	8	53	0.393	0.531
No	3	31		
LOWER BACK HINDRANCE				
Yes	4	11	3.960	0.047*
No	7	73		
LOWER BACK PAIN – 7 DAYS				
Yes	NR	NR		
No				
HIP PAIN – 12 MONTHS	NR	NR		
Yes	-	17	2.711	1.00
No	11	67		
HIP PAIN ENDURANCE				
Yes	-	2	0.268	0.605
No	11	82		

HIP PAIN – 7 DAYS				
Yes	0	2	0.268	0.605
No				
KNEE PAIN – 12 MONTHS				
Yes	-	23	3.974	0.046*
No	11	61		
KNEE PAIN HINDRANCE				
Yes	-	5	0.691	0.046*
No	11	79		
KNEE PAIN – 7 DAYS				
Yes	-	9	1.302	0.254
No	11	75		
ANKLE PAIN – 12 MONTHS				
Yes	-	16	2.520	0.112
No	11	68		
ANKLE HINDRANCE				
Yes	-	4	0.691	0.708
No	11	79		
ANKLE PAIN – 7 DAYS				
Yes	-	3	0.547	0.761
No	11	80		

Notably, serum lead level and self-reported prevalence of musculoskeletal pain (lower-back pain) were significantly associated at p-value of 0.047. Also, serum lead level and knee pain at 12 months were significantly associated at p-value of 0.046. Again, serum lead level and knee pain hindrance were significantly associated at p-value of 0.046.

Table 7 shows the association among serum lead, age, BMI and work duration.

Table 7: Association among serum lead, age, BMI and work duration

	Serum level of lead			
	Acceptable	Unacceptable	Chi-square	p-value
AGE (YEARS)				
18-24	2	24	1.008	0.799
25-34	6	33		
35-44	2	18		
45-54	1	9		
55-64	-	-		
BMI CATEGORY				
Underweight	1	8	4.060	0.255
Normal	10	51		
Overweight	1	19		
Obesity	-	6		
DURATION OF WORK				

< 6 months	1	3	18.184	0.006*
6-1yr	1	-		
1-2yrs	1	15		
2-3yrs	1	16		
3-4yrs	1	-		
4-5yrs	1	4		
>5yrs	5	47		

Notably, serum lead level was significantly associated with duration of work (< 6 months to > 5 years) at p-value of 0.006.

Table 8 shows the association between serum lead level and regional pain intensity.

Table 8: Association between serum lead level and regional pain intensity

	lead category			
pain intensity	accept	above accept	chi-square	p-value
NECK				
No pain	9	62	3.586	0.310
Mild	-	13		
Moderate	2	6		
Severe	-	3		
RIGHT SHOULDER				
No pain	8	63	8.922	0.030*
Mild	-	14		
Mod	3	4		
Severe	-	3		
LEFT SHOULDER				
No pain	10	61	3.270	0.352
Mild	-	15		
Mod	1	4		
Severe	-	4		
UPPER BACK				
No pain	11	60	4.205	0.240
Mild	-	10		
Mod	-	10		
Severe	-	4		
RIGHT ELBOW				
No pain	11	69	2.333	0.506
Mild	-	9		
Mod	-	5		
Severe	-	1		
LEFT ELBOW				
No pain	11	67	2.711	0.438

Mild	-	10		
Mod	-	5		
Severe	-	2		
RIGHT WRIST				
No pain	11	64	3.156	0.368
Mild	-	12		
Mod	-	6		
Severe	-	1		
LEFT WRIST				
No pain	11	65	3.110	0.375
Mild	-	13		
Mod	-	3		
Severe	-	3		
LOWER BACK				
No pain	3	27	5.463	0.141
Mild	-	19		
Mod	4	25		
Severe	4	12		
RIGHT HIP				
No pain	11	65	3.110	0.375
Mild	-	11		
Mod	-	6		
Severe	-	2		
LEFT HIP				
No pain	11	64	3.317	0.345
Mild	-	12		
Mod	-	5		
Severe	-	3		
RIGHT KNEE				
No pain	11	58	4.688	0.196
Mild	-	11		
Mod	-	11		
Severe	-	4		
LEFT KNEE				
No pain	11	56	5.199	0.158
Mild	-	14		
Mod	-	10		
Severe	-	4		
RIGHT ANKLE				
No pain	11	65	3.110	0.375

Mild	-	10		
Mod	-	6		
Severe	-	3		
LEFT ANKLE				
No pain	11	63	3.530	0.317
Mild	-	11		
Mod	-	7		
Severe	-	3		

IV. DISCUSSION

The average, 0.522µg/dl, and range, 0.06-1.26 µg/dl, for serum level of lead in welders in Enugu metropolis fell within the range of literature reports. Shuitz *et al* (2005) reported 0.27µg/dl and a range of 0.15-0.77 µg/dl in German smelters. Barbosa *et al* (2005) reported 0.66 µg/dl with a range of 0.02-2.9 µg/dl in men who had long term exposure to lead. Verseieck and Cornelis (1998) found the serum lead level of 1.45µg /d1 in workers exposed to lead. Also, Bergdah *et al* (2010) reported a range of 0.02-1.30µg/dl.

The normal serum lead levels in unexposed subjects have been reported as 0.020-0.054 µg/dl and 0.002–0.29 µg/dl, with mean values of 0.066 µg/dl and 0.002 µg /d1 (Balkhour, Goknil 2010; Barbosa, Trans-Santos, Gerlach, Parsons 2005; Versieck, Cornelis 1988). The increase can be attributed to occupational exposure to lead due to exposure to lead oxide in the welding processes.

A significant relationship was found in this study between serum lead levels; FVC, FEV1 and PEF. This could be as a result of the report that the prevalent route of entry of lead in the body system of welders is via inhalation before it is absorbed into the blood stream.

On the other hand, there was no significant relationship found between quality of life and serum lead levels, but a significant relationship was found between serum lead levels and low back pain, knee pain (12 months) and knee pain hindrance, which could be as a result of the oxidative nature of lead and its effect on the musculoskeletal system. The study found no relationship between serum lead level, length of exposure and age.

The prevalent low back pain among welders could be as a result of the heavy lifting and repeated trunk flexion and rotation which have been found to be risk factors for low back pain (Hoogendoorn, Bongers, de Vet, Douwes, Koes, Miedema, Bouter 2006). The welders perceived their quality of life as regards environment as average, as they reported their physical environment as being a little or moderately safe, having little money to meet their needs, moderate; availability to information needed for their day to day life, satisfaction with access to health services and time for leisure activities, and a majority reported being satisfied and/or slightly satisfied with their transportation.

The finding of cardiopulmonary functions of welders assessed in the study showed that 64.2% of the welders had an elevated systolic blood pressure above 120 mmHg and 52.6% had diastolic blood pressure elevated above 80mmHg, while only 3.2% of the welders had pulse rates above 100 beats per minute. The mean values for lung function reported for the study were FVC = 1.43, FEV1 = 1.13, PEF = 1.61, which were lower than those previously reported in literature as mean FVC of 4.73, FEV1 of 3.70 (Emam, Alissa, Gordon, Fumes 2011) and FVC of 4.97 and FEV1 of 4.15 (Golbabaei1, Monazzam, Hematjo, Hosseini, Dehghan 2013; Neighbourhood Case Research 2008; Bergdahl, Sheveleva, Schu¨tz, Artamonova, Skerfving 1988). This confirms the reports of previous studies that suggest that welders were predisposed to pulmonary malfunction due to exposure to lead. A reduction in FEV1 usually indicates airway obstruction and welding processes resulted in obstructive airway changes (Rossi 2000).

V. CONCLUSIONS

The relationships between serum lead level and cardiopulmonary function, quality of life and musculoskeletal pain of welders in Enugu, Nigeria were investigated. With serum lead level of 0.522µg/dl (0.06-1.26 µg/dl), the welders had prevalent low back pain and a very high quality of life for the domain of physical health with a score of 94, and high psychosocial and social relationship domains for quality of life with the scores of 69 and 75 respectively. About 64.2% of the welders had an elevated systolic blood pressure above 120mmHg and 52.6% had diastolic blood pressure elevated above 80mmHg, while only 3.2% of the welders had pulse rates above 100 beats per minute. The mean values for lung function were FVC = 1.43, FEV1 = 1.13 and PEF = 1.61.

The significant relationship between serum lead levels (FVC, FEV1 and PEF) could be attributed to lead inhalation. The significant relationship between serum lead levels and low back pain and knee pain could be attributed to lead's effect on the musculoskeletal system.

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Markers of Neurotoxicity: Relating the Serum Levels of Mercury, Lead and Arsenic to Quality of Life of Panel Beaters in Enugu, Nigeria

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Abstract**—** *Nigeria's life expectancy, 54.33 years, is one of the lowest globally. This is made worse by occupational hazards, especially exposure to markers of neurotoxicity, which are most common heavy metals that can be harmful to the body, including aluminum, cadmium, arsenic, lead, and mercury contained in large amount in panel beating facilities, predisposing the artisans to heavy metal toxicity. The short communication reports on the work in progress which aimed to relate serum levels to quality of life of panel beaters who are more prone to the exposure to mercury, lead and arsenic in Enugu, Nigeria. Subsequent report on the field work will carry results, discussion, implications for development, conclusion and recommendations.*

Keywords**— Heavy metal neurotoxicity, Environmental health, Occupational hazards.**

I. INTRODUCTION

At 54.33 years, Nigeria has a low figure for life expectancy among the comity of nations. Concern for heavy metals contamination is on the increase because exposure to heavy metals has risen dramatically, leading to early deaths. Each day, humans are exposed to some kind of toxins through the air, water or food and occupational hazards. Markers of neurotoxicity include most common heavy metals that can be harmful to the body are aluminum, cadmium, arsenic, lead, and mercury which are in large amount, with the last three contributing to the most cases of heavy metal toxicity (*www.SixWise.com*, 2009). Heavy metals such as metalloid, e.g arsenic, lead, copper, and others, are widely utilized to sustain the living standards of the modern world and they are able to induce toxicity at low level of exposure (Duffus, 2002; Arif et al, 2015).

Most of the environmental contamination and human exposure result from anthropogenic activities such as mining and smelting operations, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds (Goye, 2001; He et al, 2005). Environmental contamination can also occur through metal corrosion, atmospheric deposition, soil erosion of metallic ions and leaching of heavy metals, sediment re-suspension and metal evaporation from water resources to soil and ground water (Niragu, 1989). Natural phenomena, such as weathering and volcanic eruptions, have also been reported to significantly contribute to heavy metal pollution (He et al, 2005). Industrial sources include metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations and high-tension lines, plastics, textiles, micro-electronics, wood preservation and paper processing plants (Pacyna, 1996).

Anthropogenic activities often introduce antigenes, contaminants and pollutants into organism in home and work environments. Certain occupations are at higher risk for heavy metal exposure. These include dental professionals, laboratory workers, hairdressers, painters, printers, welders, metalworkers, cosmetic workers, battery makers, engravers, photographers, visual artists and potters. Heavy metals can accumulate in the body over time, causing symptoms that might not be associated with heavy metals symptoms. Often, it can be misdiagnosed for chronic conditions, such as autism, chronic fatigue syndrome, depression and multiple sclerosis. Specifically, symptoms of metal toxicity poisoning are chronic pain throughout the muscles and tendons or any soft tissues of the body, chronic malaise, brain fog, chronic infections such as candida, gastrointestinal complaints such as diarrhoea, constipation, bloating, gas, heartburn, and indigestion, food allergies, dizziness, migraines and/or headaches, visual disturbances, mood swings, depression, and/or anxiety, nervous system malfunctions; burning extremities, numbness, tingling, paralysis, and/or an electrifying feeling throughout the body (*www.SixWise.com*, 2009).

Contamination of dietary substances by chemicals and non-essentials elements such as heavy metal is known to have series of adverse effects in the body of humans and animals (D'Souza & Peretiatko, 2002). Their entry into the human systems poses a great treat to the human populations. Metals can escape control mechanisms such as homeostasis, transport, compartmentalization, and binding to specified cell constituents. Thus, they can have toxic and even lethal effects in the body. Heavy metals can cause malfunctioning of the cellular processes via displacement of essential metals from their respective sites. Also, oxidative deterioration of biological macromolecules has been found to be primarily due to binding of metals to DNA and nuclear proteins (Flora et al, 2008).

Although the toxic effects of metals depend on the forms and routes of exposure, interruptions of intracellular homeostasis include damage to lipids, proteins, enzymes and DNA via the production of free radicals. Following exposure to heavy metals, their metabolism and subsequent excretion from the body depends on the presence of antioxidants (glutathione, tocopherol, ascorbate, etc.) associated with the quenching of free radicals by suspending the activity of enzymes (catalase, peroxidase, and superoxide dismutase) (Agency for Toxic Substances and Disease Registry, 2000).

Arsenic (As) is a ubiquitous element that is detected at low concentrations in virtually all environmental matrices. The major inorganic forms of arsenic include the trivalent arsenite and the pentavalent arsenate. The organic forms are the methylated metabolites; monomethylarsenic acid (MMA), dimethylarsenic acid (DMA) and trimethylarsenic oxide (Agency for Toxic Substances and Disease Registry, 2000).

Abnormal blood arsenic concentrations (>12 µg/mL) indicates significant exposure. Absorbed arsenic is rapidly distributed into tissue storage sites with a blood half-life of less than 6 hours, unless a blood specimen is drawn within 2 days of exposure (Mayo Foundation for Medical Education, 2018; Chappell et al, 1997).

Reports on epidemiological studies show a strong association between arsenic exposure and increased risks of both carcinogenic and systemic health effects. Arsenic exposure affects virtually all organ systems including the cardiovascular, dermatologic, nervous, hepatobilliary, renal, gastro-intestinal, and respiratory systems. Research has also pointed to significantly higher standardized mortality rates for cancers of the bladder, kidney, skin, and liver in many areas of arsenic pollution. The severity of adverse health effects is related to the chemical form of arsenic and is also time- and dose-dependent (Tchounwou et al, 2003; Yedjou et al, 2006). Arsenic-based additive is used in chicken feed to promote growth, kill parasites and improve pigmentation of chicken meat. Eating commercial, non-organic chicken predisposes one to arsenic poisoning. Some other sources of arsenic poisoning include paints, rat poison, fungicides, and wood preservatives. Arsenic targets specific organs such as the blood, kidneys, central nervous system and skin systems (Agency for Toxic Substances and Disease Registry, 1992).

Mercury (Hg) is a heavy metal belonging to the transition elements. It is found in nature in elemental, inorganic, and organic forms, each exhibiting its own profile of toxicity (Sarkar, 2005). The normal whole blood mercury is usually less than 10 µg/mL. Significant exposure is indicated when the whole blood mercury level exceeds 50 µg/mL, if exposure is due to alkyl Hg, or above 200 µg/mL, if exposure is due to Hg^{2+} (Bjorkman et al., 2007). Mercury is a pollutant ubiquitous in the environment. Each year, perhaps 300,000 U.S. children are born who were exposed *in utero* to blood levels of methylmercury that are above levels thought to be safe (Clarkson et al, 2003; Mahaffey et al, 2004).

Studies on Korean adults report that mercury levels are associated with various combinations of higher fasting glucose levels, obesity, body mass index (BMI), waist circumference, higher blood pressure, insulin resistance, or higher total cholesterol or triglyceride levels. In sum,

mercury was associated with metabolic syndrome (Bjorkman et al, 2006; You et al, 2011; Eom et al, 2014; Seo et al, 2014; Chung et al, 2015; Kim et al, 2015; Bae et al, 2016; Park et al, 2016a; Park and Seo, 2016; Lee, 2017).

Lead is a naturally occurring bluish-gray metal present in small amounts in the earth's crust. Although lead occurs naturally in the environment, anthropogenic activities such as fossil fuels burning, mining, and manufacturing contribute to the release of high concentrations. Lead has many different industrial, agricultural and domestic application (Gabby, 2006). Lead poisoning refers to the health effects associated with an abnormally high level of lead in the blood stream. Exposure to lead occurs mainly via inhalation of lead-contaminated dust particles or aerosols and ingestion of lead-contaminated food, water, and paints (Agency for Toxic Substances and Disease Registry, 1992; Flora et al, 2006).

Lead is the most systemic toxicant that affects several organs in the body including the kidneys, liver, central nervous system, hematopoietic system, endocrine system, and reproductive system (Agency for Toxic Substances and Disease Registry, 1992). Lead exposure usually results from lead in deteriorating household paints, lead in the work place, lead in crystals and ceramic containers that leaches into water and food, lead use in hobbies, and lead use in some traditional medicines and cosmetics (Apostoli et al, 1998; Centers for Disease Control, 1991).

About 5µg/dL is the blood lead level of concern. Lead kills red blood cells through oxygen deprivation. It also reduces the ability to generate new red blood cells, resulting in anemia. It can cause high blood pressure which increases the risk of heart attack, stroke, and kidney disease (Farfel et al, 1991; Weatherization Assistance Program Standardized Curriculum, 2012).

According to Picciotto (2000), the main adverse effects of lead in adult population with high lead exposure include reproductive effects, such as decreased sperm count in men and spontaneous abortions in women. Chronic exposure may cause adverse effects on the blood, central nervous system, blood pressure, kidneys, and vitamin D metabolism (United States Environmental Protection Agency, 2002). The levels of malondialdehyde (MDA) in blood strongly correlate with lead concentration in the blood of exposed workers (Jiun & Hseien, 1994).

Therefore, there is the need to assess the serum levels of selected heavy metals among panel beaters in Enugu metropolis in relation to their quality of life (QOL) reflected by various symptoms of toxicity poisoning by the metals. There is paucity of academic reports relating serum levels to quality of life of panel beaters exposed to mercury, lead and arsenic materials in Africa, especially Nigeria. This study is an assessment of the relationship between serum levels and quality of life of panel beaters who are more prone to the exposure to mercury, lead and arsenic in Enugu metropolis, Enugu State, Southeast of Nigeria.

The specific objectives of the study are to ascertain the serum level of mercury, lead and arsenic among panel beaters in Enugu metropolis; quality of life (QOL) reflected in prevalence of pain among panel beaters in Enugu metropolis; and relationship between exposure to the selected metals and the QOL. The findings of this study will enlighten some artisans and the public on the health effects of markers of neurotoxicity on artisans. They will also expose the need for health professionals to engage studies on holistic health assessments of artisans in relation to occupational hazards, in order to minimize early death in a country with life expectancy at birth of 54.33 years in 2018.

II. MATERIALS AND METHODS

The study adopted the cross-sectional survey design. Convenience sampling technique was adopted based on the number of subjects available at the time of survey, met participation criteria and were willing to participate. Study population consisted of all panel beaters working and residing in Enugu metropolis, Enugu State, South-east, Nigeria. Power analysis was done using NCCS PASS 15 to determine the minimum sample size. The study was set at power (β) of 0.9, α of 0.150. Sample size obtained at second degree of freedom (df) of 2 was 60, 20, in each group. A sample size of 50 was obtained, but was increased to 100 to allow for generalization of results.

An ethical approval was obtained from the Health Research and Ethical Review Committee of a University Teaching Hospital (tertiary health institution and referral centre) that covers the area or research. The purpose and procedure of the study were explained to prospective the participant and the informed consents for both participation in the study and publishing the results with anonymity were obtained.

Selection criteria consisted of inclusion criteria and exclusion criteria. Only panel beaters in Enugu metropolis from 18 years upwards, who had worked for at least six months, were included in the study. Subjects excluded were those suffering from trauma, fracture, arthritis, neurological conditions, hypertension, cardiac problems and respiratory diseases, such as asthma.

Questionnaire used consisted of World Health Organization Quality of Life and Nordic questionnaire for

pain. The procedure for the study was explained to the subjects from whom informed consent was also sought. Two (2) questionnaires, WHO quality of life and Nordic questionnaire for pain, were given to the participants to complete. WHO questionnaire for quality of life was either self-administered by subjects who had the ability or desire to do so or administered by the researcher. It consisted of 26 questions which were explained to subjects for clarity. Nordic questionnaire for pain consisted of demographic part and other sections like pain intensity rating scale, anthropometric part, and the part for treatment intervention for pain. After completion of the questionnaire, the instrument was retrieved immediately.

The height of the participant was obtained using stadiometer (calibrated in centimeter) placed on flat surface and the bare-footed subject standing in the platform in an upright position with the heel in contact with the vertical bar of the instrument for a reading recorded immediately. Bathroom weighing scale (Hana Model) calibrated in kilogramme was used for weight measurement. The bare-footed participant stepped on the weighing scale, standing straight and looking straight at an eye level, for a reading taken immediately. For cardiovascular parameters, an automatic sphygmomanometer was used to obtain the systolic and diastolic blood pressure as well as the pulse rate. The subject was asked to stay quiet, calm and rest for five (5) minutes before the blood pressure measurement was taken. The cuff was fitted comfortably and strongly around the left bare arm 1-2 cm above the elbow joint of the seated subject with the palm supinated in front on a flat surface (desk) (WHO, 2000). A Teaching Hospital (tertiary health institution) supplied the fresh and sterile needles, syringes, blood sample bottles, cotton wool and methylated spirit imported from recognized pharmaceutical manufacturing companies in Asia, which were considered trace elements-free and used by a phlebotomists (staff of the Teaching Hospital) to collect the blood samples, who also gave a sample bottle to each subject to supply early morning urine, with an instruction to store the sample in the fridge between collection and delivery to the laboratory. The samples were analyzed by a Medical Laboratory Scientist working in the Medical Diagnostic Laboratory Unit of the Teaching Hospital for serum levels of mercury (Hg), lead (Pb) and arsenic (As) (independent variables) and the quality of life as determined by some symptoms (dependent variables) of the target artisans.

The data were subjected to descriptive statistics and analyzed using paired and unpaired sample t-test. Pearson correlation was used to determine the relationship between the variables. A probability value of 0.05 was considered statistically significant. Analysis was performed using Statistical Package for Social Sciences (SPSS) Version 20.0 for windows evaluation.

2.1 Quantitative determination of mercury (Hg)

Absorption spectrometry (dithizone colorimetry), neutron activation analysis or cold vapor atomic absorption spectrometry of the Environmental Protection Agency (EPA) of the United States of America (USA) Method – 200_13 – Trace element determination via Atomic Absorption Graphite Furnace Spectrometer using Buck Scientific Atomic Absorption Spectrophotometer (GFAAS, made in USA) was used to determine the total mercury (Bakırdere *et al*, 2013).

2.2 Quantitative determination of arsenic (As) and lead (Pb)

Arsenic and lead were determined by Environmental Protection Agency (EPA) of the United States of America (USA) Method – 200_13 – Trace element determination via Atomic Absorption Graphite Furnace Spectrometer using Buck Scientific Atomic Absorption Spectrophotometer (GFAAS, made in USA). Pd-Mg mixture was served as the matrix modifier for As, while Ni was used as matrix modifier for Pb and Cd (Bakırdere *et al*, 2013).

III. RESULTS, DISCUSSION, IMPLICATIONS FOR DEVELOPMENT, CONCLUSION AND RECOMMENDATIONS

This report is the short communication on the work in progress. The results, discussion, implications for development, conclusion and recommendations of the study will be presented in the full report to be published shortly.

ETHICAL APPROVAL

The Health Research and Ethical Review Committee of a tertiary health institution approved the study.

CONSENT TO PARTICIPATE AND FOR PUBLISHING

All subjects gave informed consent to participate in the study and for academic publishing of the results of the study with anonymity.

AVAILABILITY OF MATERIAL AND DATA

Materials and data embedded in this work are transparently available.

CODE AVAILABILITY

Materials and data are in Microsoft Word with custom code.

AUTHORS' CONTRIBUTIONS

Formal analysis and write-up – O.C. Eneh. Methodology and data curation – C.I. Ezema. Laboratory investigation – E.C. Ogbaronya. Project supervision and administration – C.K. Nwafulume.

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Development of Hatri 13ĐP Peanut Varieties for the Mekong Delta, Vietnam

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Abstract— *The new advances are applied to production, especially by the method of marker-assisted selection (MAS) in collaboration with by improved method are made to the same breeder together many desirable genes from Yuanza 9102 / ICG 12625. From the crossed Yuanza 9102 / ICG 12625 give selected one line order named HATRI 13 ĐP .The time has grown HATRI 13ĐP (95-100 days). Height plants from 60-65 cm and compared to parents . Genotype HATRI 13ĐP exhibited significantly the highest pod number (78.0/plant), Hence, these traits can be selected to improve the yield potential of pole-type peanut genotypes. Weigt of 100 seeds reached 42. 1 g compared with their parents (Yuanza 9102 =40.9 g ; ICG 12625 =36.8 g) . Grain quality with red color grain protein and total fat. Productivity of HATRI 13 ĐP has great potential in the winter-spring season, but often for low productivity in the summer, The yield 4.2 tonnes/ha of winter-spring season and 3.5 ton/ha in Wet season.This is just like having wide adaptability, stable yield, should it be production in the Mekong delta (An Giang, Can tho and Tra Vinh).*

Keywords— ***Arachis hypogaea L, genetic, plant breeding, marker-assisted selection, Microsatellite.***

I. INTRODUCTION

Arachis hypogaea L., with the common name peanut, is an important oil, food and fodder crop grown worldwide with an annual yield of 66.3 million tons and grown on 34.1 Mha (FAOSTAT, 2021). Chromosomal peanuts (AABB, 2n = 4x = 40), with a recent and unique polypoid origin, occurred 5 to 10 thousand years ago (Bertioli et al., 2019, 2020). This narrow genetic base and limited gene flow with its genetically diverse diploid wild relatives lead to a lack of alen strong alleles are resistant to pests in the main group of genes. However, the genetic basis underlying pod- and kernel-related traits in the peanut remained largely unknown, which hampered the improvement of peanut through marker-assisted selection. To understand the genetic basis underlying pod- and kernel-related traits in the peanut and provide more useful information for marker-assisted breeding(Weigang et al ., 2016) .Another limitation to recognizing yield potential is the low level of input in crop management. [World 2007]. The use of fertilizers for all crops since 2000 has averaged 11.1 kg/ha, which is not surprising enough [Hollinger et al. 2015]. However, important factors, such as phosphorus and calcium, proved to be the leading limiting nutrients for peanut production, with only 4% and 16% of farmers using chemical fertilizers or compost, respectively, in peanut production, resulting in very low yields [World 2007].Therefore, it is recommended to develop cultivars that tolerate deficiencies of both calcium and P in order to keep good crop yields. Soils in the Mekong Delta with an optimal pH of 6.0 to 6.5 for peanut growth (Tran et al 2021) often result in adequate availability of calcium and manganese . However, it is necessary to consider the acidic pH in the breeding program to predict increasing soil acidification in some areas of the country [Coulibaly et al. 2018] so yields are low. QTLs for productivity-related characteristics were observed and 29 QTL were identified(Yuning et al. 2017). The current QTL will contribute to a better understanding of the yield ingredients and linkage markers that will facilitate MAS breeding in peanuts. The genetic basis of the yield composition has been studied, and characteristics related to pods and seeds are highly valued in peanuts (Liu

et al. 2015; Shi et al. 2015) indicates that productivity characteristics depend on each other; Research objectives Choose to create a variety of peanuts for hight yield and very ease to growing

II. MATERIAL AND METHODS

2.1.Plant materials and phenotyping

Handling Crosses of Groundnut

An $F_{1\text{-}2:6\text{–}8\text{-}9}$ population of RIL lines was derived from a cross between Yuanza 9102/ICG 12625. The crossed seeds are grown along with their parents to identify hybrids. Plants in the F1 generation resembling the female parent (selfed) should be removed. The plant materials (including the parents and the RILs) used in this study were originally created by our laboratory and we have all the relevant rights to the materials. The ICG 12625 variety is hardy, well-branched, stable high-yielding with a red color . HATRI 13DP crossed was started to breed in 2017 Spring-Summer 2017 season for F1 breeding, Wet sesson crop 2017 F2, Winter Spring crop 2017-2018 F3, Spring-Summer season 2017: F4, Summer-autumn season for self-absorption F5, Winter-Spring crop 2018-2019 self-absorption F6 continues to test Summer-Autumn 2018 self-absorption F7, Winter Spring 2018-2019. Summer Autumn 2019 for Assay in Can Tho. The Seeds are harvested from F8 generation lines, for F9 self-absorption of the 2020 rainy season. Yields harvested in the first week of October 2020 were sown in the third week of February 2021. The experiment was conducted in farmers' fields in three provinces of An Giang (in Phu Tan); Can Tho (Binh Thuy) in which in Tra Vinh has three points (Tra Cu, ..All materials were grown in the field in accordance with the local legislation. The RIL population and its parental lines were planted in the experimental fields in Can Tho City .The field experiments followed a randomized block design with three replications according to a previous study with a few modifications (Huang et al 2015). For each plot, 10 plants from each RIL line were grown 15-cm apart within a row, and an 85-cm gap was given between RILs. The parental lines were planted after every 20 rows as controls. Standard agricultural practices were applied for field management. Each plant was harvested individually at its maturity to prevent loss from over-ripening. Only eight plants in the middle of each row were used for trait measurement. Mature seeds determined by full size pods carp color from each plant were measured for 100 seed weight, seed length, seed width and length to width ratio. The seed length and seed width were measured by using a parallel rule. The seed weight was taken on an electrical scale. The length to width ratio was calculated by dividing seed length by seed width. Number of leaves and number of branches: calculated at the end of the harvest period, using samples of 10 plants per test. Factors constituting yield and yield: The number of pod per plant , the number of seeds per pod are determined by counting the hull and seeds of 10 plants selected from each experiment.: Grain yield: Weigh the seed mass of the plant, collect m2. After harvesting, data is collected on each plot of 3m2 area and weighs .The mean values of each measured trait were used for phenotypic characterization.

2.2.DNA extraction

The 100 lines F3 were grown in pots. Maximum protection was employed to ensure healthy and disease-free seedlings. The leaves were collected 2-3 weeks after planting for DNA extraction.

Standard molecular grade chemicals and general techniques for preparing stock solutions, buffers, reagents, and equipment were followed according (Lang et al 2015)

DNA suitable for PCR analysis was prepared using a simplified procedure (McCouch *et al.,* 1988). A piece of a young rice leaf (2 cm) was collected and placed in a labeled 1.5 ml centrifuge tube in ice. The leaf was ground using a polished glass rod in a well of a spot test plate (Thomas Scientific) after adding 400 µl of extraction buffer. Grinding was done until the buffer turned green, an indication of cell breakage and release of chloroplasts and cell contents. Another 400 µl of extraction buffer was added into the well by pipetting. Around 400 µl of the lysate was transferred to the original tube of the leaf sample. The lysate was deproteinized using 400 µl of chloroform. The aqueous supernatant was transferred to a new 1.5 ml tube and DNA was precipitated using absolute ethanol. DNA was air-dried and re-suspended in 50 µl of TE buffer (Lang, 2002).

DNA quality checks used 1% agarose by melting 3 g of agarose in 300 ml of TAE buffer. The mixture was heated in a microwave for 5-6 min and then cooled to around 55-60 0C. This was then poured on a previously prepared electrophoresis box with combs. Gels were prepared and the combs removed after about 45 min. Seven microliters of DNA sample plus 3 µl of loading buffer (Tris 1 M pH = 8.0, glycerol, EDTA 0.5 M pH = 8.0, xylene cyanol 0.2%, bromophenol blue 0.2%, and distilled water) was run at 70-80 v, 60 mA for 45 min or until the loading buffer dye moved far away from the wells. The gel was then taken out and stained with ethidium bromide, after which it was observed under UV light.

Microsatellite analysis

The whole microsatellite analysis included PCR assay, polyacrylamide gel electrophoresis, and band detection and scoring.

PCR assay

Microsatellite primers were used to survey polymorphism on the samples. These were randomly selected from the 3 microsatellite primer pairs currently available for Peanut (SSR: GM 1494 (Guo và ctv 2012) :F'cttcgaagaaaagtgcatcg R'gaagacagaagacgaagagcgta and SNPs

Aradu_A07_1148327:F-TTGCTAATCA(**G/A**)TTGTTGGTTT(G/A);R-AAAGAAA(G/A)CCTTCCCCGA (Mounirou et al., 2020). enzyme *Hinf1 felowing* Lang et al 2015.*)*

. The PCR reaction was as follows:

Reactions were overlaid with mineral oil and processed in a programmable thermal controller set for 35 cycles of 1 min at 94 ^{0}C, 1 min at 55 ^{0}C, and 2 min at 72 ^{0}C, with a final extension at 75 ^{0}C for 5 min. After amplification, 10 µl of stop solution was added to the PCR product, which was then denatured at 94 ^{0}C for 2 min. Eight microliters of each reaction were run on polyacrylamide gel.

2.3.Data Analysis

Analysis of variance**:** The agro-morphological data collected were initially analyzed through analysis of variance to verify genetic variation in the traits measured. The few traits with insignificant genetic variation, based on the F-test, were not considered for further analysises.

Qualtility and nutritional of peanut of HATRI 13 ĐP and parents

Protein content was analyzed by the combustion method (Leco FP-528, 601500, Leco Corporation, St. Joseph, MI, USA) with a nitrogen conversion factor of 5.46. Moisture, oil, fiber, ash, and carbohydrate Foods 2020, 9, 942 3 of 14 contents were quantified according to the method of the Association of Official Analytical Chemists (AOAC.2000) .

Disease assessment Ten plants (third leaf on the main stem of each plant was sampled) in a single plot were scored for disease-resistant parameter evaluation based on 1-9 scale (1 = no symptoms, 2 = 1-5% leaf infection, 3 = 6-10% leaf infection, 4 = 11-20% leaf infection, 5 = 21-30 leaf infection leaf infection, 6 = 31-40% leaf infection, 7 = 41- 60% leaf infection, 8 = 61-80% leaf infection, 9 = 81-100% leaf infection) at day 100 after seed planting (Subrahmanyam et al., 1995). Disease incidence (percentage of infected plants), number and size of leaf spots (early and late blight leaf spots), %CLS leaf area of infected leaf, and defoliation were recorded for the incidence and severity of CLS in the plot.

The experiments were arranged in a completely random block style, 3 times repeated. The assay kit is performed by transplantation method (15 x 20 cm). Fertilizer : (35-60-60+150kg Ca and 40kg Mg). The seed set compares yields on a large scale according to farmers' farming techniques, applied pruning technique 20x20cm distance Agronomic indicators: Plant height: determined by cm ruler at the end of the harvest cycle (90 days) from the soil surface to the end of the main stem of 10 plants in each experiment.

III. RESULTS AND DISCUSSION

3.1. PCR-based MAS(maker assisted selection) in peanut breeing

DNA amplification by PCR - SSR method with GM 1494 marker In the Yuanza 9102/ICG 12625 population recorded P1 position corresponding to DNA of and P2: corresponding to GM 1494 shows that Yuanza 9102's DNA position is 200bp and the molecular size of ICG 12625 is 220bp. F_3 were developmed from the crosses Yuanza 9102/ICG 12625 , F3 individuals of the band pattern both parents . Line 1 gives the same size allele as the father (Select this line as HATRI 13DP). Demonstrated that on this population GM 1494 gives polymorphism.

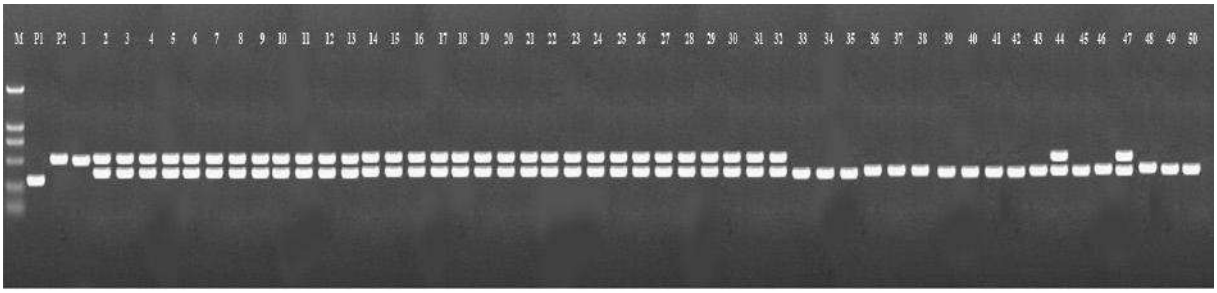

Fig.1. PCR product of the segregating population were generated by DNA amplication with primers for GM 1494 locus, on chromosome A07, positioned two the banding patterns of the parents , 220bp (ICG 12625) and 200bp (Yuanza 9102), on 3% agarose gel.

The banding patterns on the gel are the marker genotypes from which we can predict the genotypec of the plants. In MAS , DNA is extracted from segregating population derived from the cross of two parents. Digest PCR products with an enzymers to detecht a polymorphism between the PCR products from patrents DNAs F3 position carries both parents. The tightly linked gene on chromosome A07 is marked by the molecular marker Aradu-A07-1148327. This gene is associated with the particle size group according to (Mounirou et al. (2020). Aradu-A07-1148327 molecular indicator was used on F3 populations to evaluate and select the high yield of peanuts. Markers associated with yield locus in Yuanza 9102/ICG 12625 were detected in parent Yuanza 9102/ICG 12625 for polymorphism with directive Aradu-A07-1148327. The Aradu-A07-1148327 marker is used as a marker, this marker has a size of (200-210bp) and is used as a DNA mold to establish specific primer pairs. In the recorded population with 50 plants (Fig. 3) The results showed that there were 13 lines of heterozygous form. Heterozygous carrier currents from lines (2,3,4,5,6,7.10,11,12,13,14, 16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32, 44,45,46) (62%) , appearing with two bands of size 200bp - 210bp corresponding to the parents.

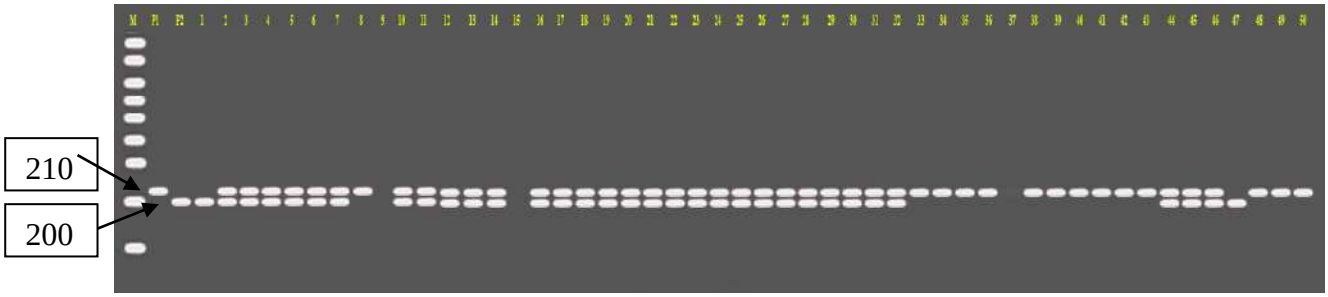

Fig.2 : PCR product of the segregating population were generated by DNA amplication with primers for Aradu-A07-1148327 locus, on chromosome A07, positioned two the banding patterns of the parents , 200bp (ICG 12625) and 210bp (Yuanza 9102), on 3% agarose gel. Digest PCR products with Hinf1 enzyme Note: P1: Yuanza 9102 P2 : ICG 12625; 1-50 is a hybrid F_3

3.2. Characters of gowth and Morphology

Assays at HATRI Institute: In general, through provincial productivity assays in terms of yield agronomic characteristics and yield composition, the results show that HATRI 13 is an elite peanut line, promising, short days, high yield, very good response from resistance to rust disease.

Table 1. Some agronomical features of HATRI 13 DP

No.	***Parameter***	**Offspring** *HATRI 13 DP*	**Female parent** Yuanza 9102	**Male parent** ICG 12625
1	Origin	Yuanza 9102 / ICG 12625	**China**	**China**
2	Growth duration *(day)*	85-90	80-85	80
3	Plant height *(cm)*	62-68	70-72	60-65
4	No. of first branch per plant	6– 6.3.0	4.0 – 5.0	5.5 - 6.0
5	Plant type	Determinant	Determinant	Determinant
6	Leaf shape	Ovate	Ovate	Ovate
7	Leaf color	Medium green	Pale green	Dark green
8	Flower color	Purple	Purple	Purple
9	Mature pot color	Yellow	Yellow	Yellow

10	Mature seed coat color	Light Yellow	Yellow	Light Yellow
11	Seed color	Red color	Dark brown	Red color
12	Diseases *(score 1-9)**			
	- *Rust*	1	3	1
	- *Black spot*	1	3	1
	- Brown spot	0	1	3
13	Lodging resistance *(score 1-3)*	1 - 2	1	2,4-6,9
14	Rate of two seed per pod (%)	77.7	68.5	58.9
15	100-grain wgt *(g)*	42.1	40.9	36.8
16	Yield (ton/ha) (dry-Wet Season)	4.19-3.5	3.8-3.5	2.7-2.3

- Characters of gowth and Morphology: HATRI 13 ĐP variety belongs to short duration group (85-90 days), equiveleant to its parents; growing type of determinate, erect type of plant, ovate leaf shape, medium plant hight (62-68 cm) and high number of first branch (2,3-3,0 braches) which is middle of parents; HATRI 13 DP has purple flower, big light yellow seed and brown hilum color of seed...

- Ability to resist biotic and abiotic stress: HATRI 13 ĐP has performed wide adatability. It can be cultivated in 3 crop season per year (Spring, Summer and Fall-Winter); well resistant to drought (this trait was received from its female parent, Yuanza 9102) and quite well resistant to drought, heat (this trait was received from its male parent, (ICG 12625). HATRI 13 ĐP has good resistant to Rust (score 1), black spot (score 1), Brown spot (score 1-3)... ; good lodging resistance (score 1-2).

- Yield components: HATRI 13 ĐP has more number of pod per plant than that of Yuanza 9102 (27-40 pods) and high P100 seed (42.1 g) equivalent to Yuanza 9102 (40.9g) and higher than that of ICG 12625 (36.8); HATRI 13 ĐP has rate of two seed per pod higher than that of Yuanza 9102 (68.6%) and ICG 12625(58.95).(Table 2)

Table 2. Some agronomic properties (height plants and duration) of winter-spring peanut varieties 2021

no	lines	height Plants(cm)	First flowering date (days)	Final flowering date (days)	duration(days)	Branch
1	Yuanza 9102	68.5b	38a	45a	100a	4.99c
2	ICG 12625	69.6b	37b	44b	96b	5.67b
3	HATRI 13ĐP	68.1b	37b	44b	90c	6.50a
4	MD7 (Checked)	72.0a	36c	44b	95b	5.8b

Ngày ra hoa đầu tiên

Peanuts: most varieties have an average growth time in this summer-autumn crop of 95-100 days, lasting longer than the winter-spring crop, possibly due to prolonged rains and waterlogging suitable for monoculture areas or intercropping with other crops. Flowering varieties concentrate 35-38 days after sowing, the flowers bloom profusely during the 1st flowering Table 2 . The present study concluded that there are no significant differences on plant height with HATRI 13 ĐP with their parents , but there is significant difference in the weight of pods, % pods 3,2 and 1 seeds , number of yield provide by ANOVA test (Table 3)

Table 3: Yield and yield of components of peanut varieties dry season 2021 at Tra Cu , Tra Vinh

No	Lines	Yield (ton/ ha)	% pods 3-4seeds	% pods 2 seeds	% pods 1seeds	% pods unfilling	P100 pods (g)	P100 seeds (g)
1	Yuanza 9102	6.06a	0.00b	83.4a	10.6c	5.96c	105.8b	40.9b
2	ICG 12625	3.42c	21.5a	58.5c	12.9b	7.07b	102.8bc	36.8c

3	HATRI 13ĐP	6.19a	0.00b	77.7b	13.9a	4.48d	95.9cdef	42.1a
4	MD7 (Checked)	5.97b	0.00b	77.5b	13.9a	8.79a	92.3defg	40.2b

3.3.Multi-point assay

Assessing the genotype and environmental interactions of peanut lines on the yield of peanut varieties in the Winter Spring 2021 crop Normally a newly recognized variety must have high stability and adaptation to different environments along with high yield factors and good agronomic properties to improve variety reliability. When grown in various locations to assess their stability and adaptation, some of their agronomic characteristics and yields are likely to change. The main cause of differences in adaptability and stability between breeds is the interaction between genotype and environment. This causes a lot of difficulties in proving the superiority of a breed. The phenotype of a body is regulated through the control of the genotype and environment. The variability of the phenotype in the environment is not the same in all genotypes, the result of phenotypic variation depends on the environment.

In cases where there are multiple types of interactions, then theoretically there is only one type of interaction in which the same genotype becomes the best genotype across all environments (Chahal and Gosal, 2002). In fact, such genotypes may not be present, or can hardly develop and identify. Interference-type interactions become more realistic. Such an interaction will indicate which genotype is adapted to the environment. Non-interferometric interaction patterns affect the nature and importance of genetic variance components, on the other hand they are related to parameters such as: genetic coefficient [h2], selective efficiency [GA]. Such genotypic complexity makes improving crop yields dependent not only on the artistic ingenuity of the breeder, but also requires a full scientific understanding of biological statistical analysis through seed assays across various sites, for rice in particular and all crops in general according to (Lang et al 2016)

Experiments evaluating adaptability and stability are usually conducted in environmental conditions other than space (place) or time (season) or both space and time. This allows us to apply the Eberhart and Russell, 1966 model to understand the interaction between genotype (G) and environment (E). Experiments evaluating gene and environmental interactions of prospective hybrid lines were conducted on a large scale. The experiment was conducted at six sites representing rice regions in the Mekong Delta: An Giang, Can Tho, Tra Vinh (three sites : Tra Cu, cau Ngang and Duyen Hai), and the experiment was conducted in two Winter Spring 2020-2021 crops. The results of rice yield assessment across 5 locations: An Giang, Can Tho, Tra Vinh, of the peanut seed/line in the Winter Spring 2021-2022 season are presented through Table 4. The results of the productivity movements showed that the F test was statistically significant at 1% in terms of the linear hypothesis of the environment, like, interacting with the environment. This allows us to use the environmental index (Ij) symbol for each place, on the interaction diagram between the genotype and the environment with the order from unfavorable to favorable as follows: Can Tho , Tra Cu, Duyen Hai,An Giang , Cau Ngang is on the Ij axis with the value in: 0.103; 0.003; 0.022; 0.017; -0.08 respectively .

Table 4: Yield (ton/ha) of peanut seed/line at 5 sites at winter-spring 2021

Lines	Can tho	Tra Cu	Duyen Hải	An Giang	Cau Ngang	Yield(ton/ha
HATRI01ĐP	4.32	7.21	5.45	5.95	4.2	5.43
HATRI02ĐP	4.71	7.59	5.84	6.34	5.6	6.01
HATRI03ĐP	3.69	7.58	5.82	6.32	5.1	5.7
HATRI06ĐP	3.91	7.79	6.04	6.54	7.5	6.35
HATRI14ĐP	4.5	7.38	5.62	6.12	7.5	6.22
HATRI15ĐP	3.29	7.18	5.42	5.92	6.2	5.62
HATRI 13ĐP	**4.94**	**7.81**	**6.06**	**6.56**	**7.8**	**6.63**
HATRI 20ĐP	3.2	7.08	5.32	5.82	4.6	5.21
HATRI 8ĐP	3.19	7.06	5.31	5.81	5.8	5.41

MD7	2.56	7.44	5.69	5.19	6.6	5.45
Mean	**3.83**	**7.41**	**5.65**	**6.07**	**6.09**	**5.49**
IJ (Envicroments Index)	**0.103**	**0.003**	**0.022**	**0.017**	**- 0.08**	

In terms of rice varieties, most hybrids have an average yield higher than the control MD 7 variety (5.87 tons/ha). The difference in the yield of the varieties is significant at 5% based on a scale that evaluates productivity through multi-point analysis. The yield at Tra Cu (7.41) next Cau Ngang (6.09ton / ha), followed by An Giang (6.07). Analyzing ANOVA yields of 14 rice varieties 5 environments, the difference in the yield of varieties is very statistically significant at 1%, but the level of stability in yield, as well as adaptability manifests itself very differently, through GxE (linear) interaction is very significant. The results of the ANOVA analysis allow to consider the interaction between the breed and the environment here to be linear. In the Winter Spring 2021 season, it is clear that the yield of the lines compared to the control variety is superior such as the HATRI 13 DP line (Yield 6.63 tons / ha).

3.4. Reaction to disease

The main causes of peanut damage are rust disease is an economically important biotic stress that significantly reduces the pod and fodder yield and oil quality. It is caused by the basidiomycete fungus Puccinia arachidis *Speg*. which belongs to class *Pucciniomycetes* like other rust fungus but has fewer occurrences in teliospore form. The *P. arachidis* predominantly spreads by the repeated cycle of uredospores in the field. The disease is prevalent in most of the countries where peanut is cultivated and favored by warm and humid climatic conditions such as Tra Vinh province. Despite its economic importance, very limited work has been carried out on host-fungus interaction, fungal genetic diversity, and physiological specialization. Rust disease appears only at the end of the growth and development of peanuts. In the early stages, it is rare and the disease develops very strongly in the late stages. Peanut varieties participating in the experiment suffered from iron disease from points 1-2 points at this stage 60 after sowing, points 2-5 points 90 days after sowing.

Brown spot (*Cercospora arachidicola*), black spot (*phaeoisariopsis personala*).Brown spot and black spot disease appear earlier than rust spot disease from the start of flowering causing severe harm at the 90-day period from points 1-5 points for brown spots, 3-5 points for black spots. The MD 7 variety suffers from the most severe brown and black spot disease after 90 days .

Table 5: Resistance categories for reactions of peanut genotypes to diseases.

Lines / Desease	**Rust dease**			brown spot			black spot		
Times	**30**	**60**	**90**	**30**	**60**	**90**	**30**	**60**	**90**
MD7 (checked)	**0**	**2**	**5**	**0**	**0**	**3**	**0**	**0**	**5**
Yuanza 9102	**0**	**1**	**4**	**0**	**0**	**2**	**0**	**0**	**4**
ICG 12625	**0**	**1**	**1**	**0**	**1**	**3**	**0**	**1**	**1**
HATRI 13ĐP	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**

3.5. Qualtility and nutritional of peanut of HATRI 13 ĐP and parents

Peanuts have a strong nutritional. They are an excellent source of plant-based protein, fiber, and many key vitamins and minerals.

- Results of analyzing seed quality indicated that in Fall-Winter crop 2021, HATRI 13 DP has good quality .The proximate composition of defatted peanuts is shown in Table 6. The largest fraction in both peanut meals was protein content, ranging from protein content of 24.5 g .Protein HATRI 13 ĐP was significantly higher than in Yuanza 9102(22.3 g). Carbohydrate was the second largest fraction, found in the range of 16.13 g lower to Yuanza 9102 (17.2g) higher than ICG12625 and MD7.The total fat and crude fiber in HATRI 13 ĐP (43.43 and 8.4, respectively) were significantly different to those in Yuanza 9102 (39.2 and 7.8 respectively) ($p < 0.05$). Minerals and vitamine content can be reduced by the re-extraction process, increased contact time, or adjustment of the solid–liquid ratio. (Table 6). Minerals : postassium lower mother (Yuanza 9102)but hight father(ICG 12625) . Results of analyzing seed quality indicated that in Fall-

Winter crop 2021, HATRI 13 DP has good quality (protein content of 24.5g and lipid of43.43 g).(Table 6)

Table 6: Nutritional value per 100 g of HATRI 13 ĐP and Parents

Information	Contents	HATRI 13 ĐP	Yuanza 9102	ICG 12625	MD7
macronutrients	protein(g)	24.5	22.3	25.2	23.2
	carbohydrate(g)	16.13	17.2	15.7	16.1
	fiber(g)	8.4	7.8	7.7	8.1
	sugars(g)	4.72	4.1	4.2	3.85
fats	Total Fat (g)	43.43	39.2	43.05	39.56
minerals	potassium(mg)	702	712	623	625
	phosphorous(mg)	356	320	378	256
	magnesium(mg)	160	152	161	153
	calcium(mg)	95	90	96	79
	sodium(mg)	17	15	17	13
	iron(mg)	4.58	5.26	5.74	3.56
	zinc(mg)	3.77	3.56	3.02	3.52
	Copper(mg)	1.356	1.421	1.253	1.461
vitamins	vitamin B-3 (niacin)(mg)	11.89	12.1	10.52	11.23
	vitamin E (alpha-tocopherol)Mg)	8.33	7.56	8.23	8.12
	vitamin B-1 (thiamine)mg	0.64	0.55	0.62	0.6
	vitamin B-6 (pyridoxine)(mg)	0.35	0.44	0.32	0.021
	riboflavin (vitamin B-2)(mg)	0.16	0.08	0.1	0.12
	folate (vitamin B-9)(mcg)	245	215	245	241
	Vitamin C	0	0	0	0
	folate (vitamin B-9)(mcg)	245	215	245	241
	Vitamin C	0	0	0	0

Fig.3. HATRI 13ĐP growing at Tra Cu (Tra Vinh province)

IV. DISCUSSION

HATRI 13DP variety has significant value in height, number of branches/trees, number of seeds/trees, volume of 100 seeds, number of nodules/tree. Yield and kernel yield as well as particle size are both higher than MD 7. In addition, HATRI 13DP is a large seed cultivar, so it needs more fertilizer application than MD7. The traits of the number of seed pods per plant observed in this study confirm the findings and report significantly significant variable traits in terms of the number of seed pods per plant as reported by (Waghmode et al., 2017). the loci control the traits that determine productivity distributed across the entire genome, which also indicates a complex genetic basis of the traits that determine productivity. It is also possible to replicate QTLs with moderate phenotypic changes for seed size and weight in peanuts as well as in soybeans (Xie et al. 2014). Single-locus markers have many advantages in molecular genetics and breeding studies compared with multi-locus markers (Jin et al.,2010). The alleles of single-locus markers can be assigned to particular genomic loci in diversity analyses, preventing problems of extensive genome duplication and homology within and between different genomes caused by multi–locus markers of polyploidy (Li et al 2013).In this study, Use PCR product of the segregating population were generated by DNA amplication with primers for GM 1494 locus, on chromosome A07, positioned two the banding patterns of the parents , 220bp (ICG 12625) and 200bp (Yuanza 9102) at F3 popluation. We also investigated whether the motif type, repeat length and repeat number influence the polymorphism locus SNP markers for Aradu-A07-1148327 locus, on chromosome A07 . With 4 peanut genotypes were detected showing different levels of resistance to Brown spot caused by *Cercospora arachidicola* and P. personata. Genotypes ranging from brown spot resistant to brown spot susceptible were observed in a field study. Differences in infected leaf area percentage among peanut genotypes provided useful information. A differential response to infection by the fungal causal agents of early and late blight existed among peanut genotypes with different inherent levels of resistance. The resistance parameters including the number of rust , brown spot and black spot , size of leaf spots, and infected leaf area percentage could differentiate genotypes into resistant and susceptible from pearence and . The results of this study indicated that genotypes HATRI 13 ĐP , and ICG 12625 were consistently tolerant to CLS under field conditions . Peanut is an important crop grown worldwide. Commercially it is used mainly for oil production but apart from oil, the by-products of peanut contains many other functional compounds like proteins, fibers, polyphenols, antioxidants, vitamins and minerals which can be added as a functional ingredient into many processed foods(Shalini et al.,2016) . Results of analyzing seed quality indicated that in Winter crop 2021, HATRI 13 DP has good quality (protein content of 24.5g and lipid of 43.43 g) and were

significantly different to those in Yuanza 9102 and ICG 12625 (Table 6).

V. CONSLUSIONS

Peanut variety, HATRI 13ĐP was bred using cross pollination method from Yuanza 9102/ICG 12625 , growth duration from 85-90 days (in Summer and Fall-Winter crop season), hard stem, good growth and development, wide adaptability, and can be cultivated all two seasons per year. HATRI 13ĐP has high yielding potential, high P100 seed (42.1g), with beautiful yellow seed, protein content of 24.5 g and tolat fat of 43.43g . Results of production testing for HATRI 13ĐP the Mekong delta provinces showed that HATRI 13ĐP has wide adaptability in many different ecological zones such as :Tra Vinh Province, An Giang Province and Can Tho City.

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The effect of replacing soybean meal with Fava bean seeds in daily ration of Lebanese Baladi goat kids and Awassi sheep lambs: 1- Body performance

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Abstract— *The aim of the study was to investigate the partial and complete substitution of imported soybean meal (SBM) with Fava bean seeds (FBS) in Awassi male lambs (S) and local Baladi goat kids (G) rations and the consequences on body performance. Fifteen growing lambs and 15 growing kids, with an initial bodyweight of 23.09 and 14.90 kg with 100 days of age, respectively, were fed cotton-seed meal (CSM), wheat bran and corn-based diet supplemented with protein legume sources, 75% FBS :25% SBM (S75 & G75), 0% FBS :100% SBM (S100 and G100-positive control) and 100% FBS :0% SBM (SC0 & GC0- negative control). Awassi lambs of all groups had comparable average feed intake (FI) accumulating between 43.9 and 49.4 kg/head and live body weight gain (LBWG) between 6.5 and 10.9 kg/head. Whereas local Baladi goat kids attained a cumulative LBWG levels of 5.7 and 3.96 kg/head and cumulative FI of 28.2 and 29.7 kg/head. Feed conversion ratio (FCR) for lambs attained the best results in group S50 (3.92) and the least in S100 (6.82) and for kids 7.14 in G100 and 5.25 in G75 groups. Feeding group S50 with 50% FBS and 50% SBM in based-ration gave more profit 17.2% than all other groups in comparison with SC0. On the other hand, G75 gave the highest profit by 19.15% in goat kids. Most notably, omitting soybean meal with or without additional protein legume as fava bean seeds replacements resulted in comparable high-body performance level.*

Keywords— ***Soybean meal, fava bean seeds, Awassi lambs, goat kids, feasability.***

I. INTRODUCTION

The need for alternative protein sources to soybean meal (SBM) in domestic animal feeding has recently gained focus. The main reasons include the attempt to limit SBM import from extra-EU Countries, which represents a negative voice of the commercial balance; an effort to decrease costs of animal production and contemporarily reduce the loss of N-compounds in the environment and the search to prevent the presence of GMO (Genetically modified foods) in the food chain (Wilkins and Jones, 2000; Mordenti and De Castro, 2005; Formigoni *et al.*, 2007). Among the possible protein sources, lupins, peas and fava beans *(Vicia fava L.)* were successfully used in ruminants and nonruminants (Burel *et al.*, 2000; Bonomi, 2005; Moschini *et al.*, 2005; Masoero *et al.*, 2006; Vandoni *et al.*, 2007; Keller *et al.*, 2021). Demand for pulses for stock feed both locally and in export markets is likely to have a major influence on prices. Pulses are valuable stock feeds because of their high protein levels and palatability (Henchion *et al.*, 2017). They can be used as part of intensive livestock rations or as supplements for stall reared stock. In some countries lupines are generally the preferred pulse for sheep and cattle because of their higher protein, higher fiber and lower starch levels, but peas and fava beans (FBS) are also useful and are commonly used overseas (Zagorakis *et al.*, 2018a). Pulses

are used in intensive rations to provide energy and essential amino acids for growth (Beigh *et al.*, 2017; Poutanen, 2022).

Small ruminant's production contributes to the livelihoods of a large number of farmers and accounts for 28-58 % of agricultural output in the Middle East (Iniguez, 2005). In Lebanon small farmers in marginal lands, where milk constitute an important source of income (Hosri and El khoury, 2004; De Rancourt *et al*., 2006; Hosri, *et al*., 2016), mainly conduct it. Awassi lamb-fattening and goat-fattening systems in Middle Eastern countries are popular because they can rapidly generate income. Nevertheless, feed costs constraining these systems and seasonal fluctuations in feed prices expose farmers to risk. Despite the important relative size of the small ruminant's flock in Lebanon (330000 head of sheep and 450000 head of goats (FAO, 2010), the sector is facing many difficulties.

The outbreak of BSE in the 1990s caused proteins of animal product to be banned as feed, but now it will be permitted for non-ruminants (Minchin, 2021). A large integrated Project called "Grain Legumes" is combining the efforts of scientists from 18 countries in order to make legume crops more competitive for European agriculture, using the latest progress in genomics and ranging from plant improvement and crop management to feed processing. Existing protein sources are primarily hindered by their negative environmental impacts with some concerns around health. However, they offer social and economic benefits, and have a high level of consumer acceptance (Henchion *et al.*, 2017; Małecki *et al.*, 2021)

Duc (1997), Haciseferogullari *et al.* (2003), Hossain and Mortuza (2006), Crepon *et al.* (2010); Yah Konfor (2013) and Mayer Labba *et al.* (2021) published that the nutritional value of fava bean has always been traditionally attributed to its high Protein content, which ranges from 27 to 34% depending on genotypes, Oil, 1.2 g; Crude Fiber, 5.1 g; Starch, 51 %; Sugars, 5 %; Iron, 4.2 mg; Thiamin, 0.45 mg; Riboflavin, 0.19 mg; Niacin, 2.4 mg; Energy, 328 kcal. Most of these proteins comprise of globulins (79%), albumins (7%) and glutelins (6%). In addition, Berrazaga *et al.* (2019) found that the nutritional value of fava bean was 87 and 31% for DM and CP, respectively. Legume seeds contain several comparatively minor proteins including trypsin inhibitors, lectins, lipoxygenase and urease, which are relevant to the nutritional quality of the seed (Bartsch and Valentine, 1986; Halmemies-Beauchet-Filleau, 2018).

Hanbury *et al*. (2000), Yin *et al.* (2011), Watson *et al* (2017), Yaacoub and Al Jammal (2018), Yaacoub *et al*. (2018), Halmemies-Beauchet-Filleau (2018), Lestingi *et al.* (2019), Ibáñez *et al*. (2020) and Parisi *et al.* (2020) reported that, to reduce reliance on imported soybean meal (SBM) in temperate environments, fava bean might be alternative protein sources for small ruminant diets. Surra *et al.* (1992), El Maadoudi (2004), Delmotte and Rampanelli (2006) noted that Fava bean is highly palatable for lambs, which prefer it to barley. In lambs, including fava beans up to 50% in the diet did not affect meat quality when compared to soybean meal Antongiovanni *et al.* (2002), Lanza *et al.* (2007) and Emiola and Gous (2011). Mullan (2001), FAO (2002), Connell and Hafi (2003), Mukherjee *et al.* (2016), Sedláková *et al.* (2016), Addisu (2016), Shi *et al.* (2017), Naumann *et al.* (2017), Choi *et al.* (2019), Samtiya *et al.* (2020), Te Pas *et al.* (2021), Mazumder *et al.* (2021), Mayer Labba *et al.* (2021) and Landi *et al.* (2021) stated that bean, chickpeas and lupine cultivars grown in most countries of the World tend to have now low tannin, vicine and covicine in their seed coats. Cerioli *et al.* (1998) and Shi *et al.* (2017) concluded that the bean has a lower content of trypsin inhibitors than the soybean and no urease activity but contains more tannins. Aplocina and Veipa (2015) reported that fava beans could be used in dairy rations at inclusion levels of up to 35%.

To our knowledge, the present study is among the firsts to focus on the effect of feeding FBS (fava beans) on body performance in Lebanese local *"Baladi"* goat and Awassi sheep breeds in fattening production. Therefore, data on the effect of FBS on body performance of fattening and meat quality of locally reared small ruminants are scarce.

The aim of our experiment was to evaluate the influence and feasibility of replacing totally or partially soybean meal with fava beans in rations fed to weaned lambs and kids of local Awassi sheep and local goat breeds (*Baladi*) on health and some traits of body performance.

II. METHODOLOGY

This experiment was divided into 2 trials: Trial I was conducted at "*Jarrah sheep farm*" at West Bekaa/Lebanon 5 Km of Zahleh (Bekaa district), 75 km from Beirut/Lebanon during May-June 2015. Relative humidity (RH %) and environmental temperature (T°C) that were recorded during this period of the year ranged between 50.3 - 76.9 and 26.6 - 24.6, respectively. Fifteen weaned Awassi male lambs weighing 23.33 ± 0.52 kg started a fattening experiment at the age of 100-120 days. The lambs were born with an average birth weight (BWT) of 4.23 ± 0.73 kg. Trial II was conducted during May-June months- 2015 for eight consecutive weeks on weaned male kids of local "*Baladi*" goat kids in Bziza at "*Ghattas animal farm*" in North-Lebanon (North district) 100 km

from Beirut. Relative humidity (RH %) and environmental temperature (TºC) that were recorded during this period of the year ranged between 57.6 – 79.1 and 28.5 - 25.1, respectively. Fifteen Kids with 13-14 weeks of age were fattened having an average live body weight (LBW) and at the beginning of the experiment (data collection) of 14.90 ± 0.259 Kg.

At the beginning of the trial and with the initiation of the preparatory period, (2 weeks) animals were dipped and treated for all kinds of helmentic worms. Besides, they were ear tagged and vaccinated against Anthrax and FMD; Albendazole was administered with drinking water as prevention for digestive tract parasites. Veterinary inspection was repeated every week where intramuscular injections of multivitamin dozes (A, D & E) were administered. The animals were in good health (veterinary examination).

All experimental animals (Trials I & II) were distributed randomly into five groups by 3 animals each under typical ecological and management conditions of environment (humidity and temperature) and fed five experimental rations as shown in Table 1. A combination (1:1) of good quality wheat straw and green hay was fed *ad libitum*; clean fresh water and mineral blocks (lickers) were available all the time inside the animal pens (2 x 2 m^2/group). Each animal-group was fed daily free choice forage feeds and around one and a half kg of the experimental mix-rations in feeding troughs and fresh water. All rations were isocaloric (2.9 Kcal/kg ME) and adjusted to the same level of crude protein (17%) as recommended by NRC (1989) and based on cotton seed meal (CSM), wheat bran and corn, fed continuously with different levels of Soybean meal (SBM) : Dry milled Fava bean seeds (FBS) for the whole experimental period.

Animals were assigned to the following five experimental rations (See table 1): The basal ration was adjusted to the recommended requiremnts of crude protein and energy by adding different levels (%) of cotton seed meal (CSM), wheat bran, corn and supplemented with different combination of soybean meal (SBM): fava bean seeds coarsely milled (FBS).

- Experimental groups - S25 (Sheep) & G25 (Goat) where FBS partially replaceing 25% of the SBM is added to the basal ration (25% FBS: 75% SBM).
- Experimental groups - S50 (Sheep) & G50 (Goat) where FBS partially replacing 50% of the SBM is added to the basal ration (50% FBS: 50% SBM).
- Experimental groups - S75 (Sheep) & G75 (Goat) where FBS partially replacing 75% of the SBM is added to the basal ration (75% FBS: 25% SBM).
- Experimental groups - S100 (Sheep) & G100 (Goat) where FBS totally replacing 100% of the SBM is added to the basal ration (100% FBS: 0% SBM).
- Experimental control groups - SC0 (Sheep) & GC0 (Goat) where this control ration was composed of 100 % SBM and no inclusion of FBS supplementing the basal ration (0% FBS: 100% SBM). In addition, this ration represents commercial feeding in fattening lambs and kids used at the Lebanese farms following the indoor keeping system.

Roughages (commercial wheat straw and green hay) were fed free choice. Experimental concentrate mixtures were fed starting with half kg/head daily (average) and adjusting the amounts given as the animals progressed in growing (in calculation to 3% of live body weight). Since it was very difficult to construct animal pens with individual feeding boxes, it was agreed to have group- feeding (3 lambs and 3 kids in each group with one common feeding trough). In order to know properly the amount of concentrate mix to be fed daily to each group during the whole week, it was allowed to adjust the amount once per week in the morning after each weighing by multiplying the 3% of the highest live body weight in each group by 3 (animals) and by 7 (days) and then at feeding time one of seven equal proportions was distributed in each animal group for seven consecutive days of the week. Half of the daily concentrate-mixn was offered in the morning and the other half in the late afternoon.

It was very significant to have knowledge of the cost price of the different ingredients used in the daily rations to figure out any profit in using them. Table 1 shows the actual prices in $USD paid ($/ton) for purchasing the ingredients during April-May months of the 2015 year prices at the Lebanese market and the calculations per ton of the rations prepared ($/Ton).

Table 1. Experimental concentrate-rations composition (% as fed basis) fed to lambs and kids

Cost price of Ingredients ($/ton)	Ingredients	S25/G25 75% SBM+ 25%FBS	S50/G50 50% SBM+ 50%FBS	S75/G75 25% SBM+ 75%FBS	S100/G100 100% FBS	SC0/GC0 (Control) 100% SBM
600	SBM	11.1	7.4	3.7	0.0	14.8
325	CSM	7.4	10.0	13.0	15.8	5.1
350	FBS	3.7	7.4	11.1	14.8	0.0
150	Wheat bran	16.0	15.0	12.7	12.3	14.7
250	corn	61.7	60.1	59.4	57.1	65.4
	Total	100.0	100.0	100.0	100.0	100.0
	CP	17.9	18.0	17.9	17.9	18.0
	ME Mcal/kg	2.85	2.52	2.94	2.28	2.96
	Cost price of rations ($/ton)	282	276	271	264	291

Refused feeds (what was left behind in the feeding troughs) from each pen if existeded were collected, weighed and recorded each week in the morning before the start of group-feeding. The trial proceeded for 8 weeks (collection of samples for analyses) after a preparatory period of 2 weeks to become adapted and acclimatized with the new experimental conditions.

Measurement of samples and calculation of Variables.

- Before initiation of the experiment, all concentrate-rations under investigation were chemically analyzed (percentage) for (AOAC, 1995): Dry matter (DM) content of the ration and each ingredient used; crude protein (CP); ether extract (EE); crude fiber (CF); ash.
- Health problems were inspected daily for indigestion and possible malnutrition and levels of mortality (if exist).
- Live body weights of each animal were recorded using typical balances: At the beginning of the preparatory period; at the initiation of the experiment; at the beginning of each week; at slaughter.
- The weekly cumulative feed intake in each group (wcFI/group) which is the total feed intake during the completely experimental period (8 weeks) was calculated by accumulating the weekly feed (wFI) intakes for each group.
- Weekly live body weight (wLBW) of each animal was measured at the start, end and during the experimental period on weekly basis (in the morning before feeding).
- Cumulative live body weight gain (cLBWG) was calculated by accumulating weekly LBW for the whole period or by subtracting the initial weight at the beginning of trial (W_0) from the final weight (W_f).
- Feed conversion ratio (FCR) at the end of the trial in each group was achieved by dividing total feed intake for the 8 weeks (FI) by total LBWG for the whole period.

Feasibility study and profitability calculations

Feasibility calculation of using the ingredients in concentrate mix rations containing SBM with/without FBS and meat profitability was achieved to show whether it is feasible and profitable using FBS, taking into consideration prices paid during May-June/2015 (Table 2).

Statistical analysis

Data were analyzed using the analysis of variance (ANOVA) procedure (Statistica, 2020). The experimental design was a randomized block design, with three replicates per treatment (3 x 5). Analysis of variance techniques were used to assess the statistical significance ($P<0.05$) of treatment effects. Feed intake (FI) and food conversion ratios (FCR) in each animal group were analyzed as apparent feed intake (aFI/head) and apparent feed conversion ratio (aFCR/head). Interaction and comparison among means was tested using the All Pair wise Multiple Comparison Procedures (Bonferroni test method) at a level of 5% significance. Mean ± SD (Mean values of the traits ± Standard Deviation) is used in all obtained statistical studies.

III. RESULTS AND DISCUSSION

Animal health and feed palatability

No health problems were noticed. The animals were in good health, no signs of indigestion or diarrhea or any blood signs in manure were observed. Moreover, the appetite as observed in all groups was acceptable where no left behind ration remaining was collected. The feed intake (FI) by all lambs and kids in all groups fed the different rations was 100 % palatable *(personal observations)*.

Experimental animals and feeding.

Random distribution of all lambs resulted in almost equal average weight among the five animal groups. The difference in the average initial Live Body weight (23.09 ± 0.52 kg) was statistically insignificant (P>0.05), where it ranged from the lowest as 22.8 ± 0.70 kg in group S100 and the highest as in S50 (23.70 ± 0.60 kg). Moreover, results obtained show that the difference in the initial kids live body weight (LBW) of all experimental animals (14.90 ± 0.259 Kg) were statistically non-significant (P>0.05) calibrating from 14.77 kg in GC0 (control group) to 15.03 kg as in group G25.

The results of the proximate chemical analysis analyzed on concentrate-ration samples before the initiation of the experiment, coincides with the proposed rations constructed where CP, EE, CF, Ash and calculated ME did not exceed 18%, 5.2%, 13%, 5.6% and 2.96 MCal/kg, respectively, as fed basis. Note that this was in agreement with the nutrient requirements of small ruminants as proposed by NRC (1989).

The amount of concentrate mix fed to lambs and kids for the whole period of the experiment did not exceed 49.35 and 30 kg/animal group respectively. In 1st week, the apparent daily feed intake (adFI) per animal in all groups averaged to 703 and 450g whereas, at the end of 8th week this value increased to 959 and 550g/head respectively, as 3% of live body weight recalculated as an average after weighing all the animals at the beginning of each proceeding week.

Measurement of samples and calculation of Variables.

Feed Intake (FI)

Data obtained show the weekly average variation in lambs (P<0.05) and kids FI (P>0.05) among groups from 1st week until the end of the experiment. The highest waFI for the 8 weeks was registered in group S50 (6.17 kg/head) vs G75 (4.3 kg/head) and the lowest in group S100 (6.17 kg/head) vs G100 (3.9 kg/head). This might be related to the fact that as Fava bean seeds (FBS) increases in the ration, FI decreases as in animal group G100 and the best was optimized in group G75 whose animals were consuming SBM on the level of 25 % of FBS in concentrate mix. Close to, this level was observed in animal group GC0 where FBS was not added (0 %). One explanation to this tendency is the complementary factor in both ingredients making them when mixed together more convenient for the goats to consume more and gain more making the diets more palatable.

The highest overall feed intake (FI) at the termination of the experiment was obtained (Fig. 1) in group S50 (49.35 kg) significantly higher (P<0.05) than S100 (43.94 kg) and S25 (45.94 kg) with a tendency to be higher (P>0.05) in groups S75 (47.34 kg) and SC0 (46.82 kg). In other words, animals of group S50 that consumed ration consisting of 50% FBS and 50% SBM was higher by 7.4%, 4.2%, 12% and 5.4% than that in S25, S75, S100 and SC0, respectively. In relation to kids G100 attained the least values by 28.2 kg and the highest in G75 (29.7 kg) at the end of the experiment (P>0.05). Once more this might be related to the fact that rations fed to animal-group G100 did not contain SBM and only 100 % FBS making the consumption of rations for goats lower than any other legume-ingredients combination. As SBM decreases and FBS increases in rations we observe an increase (P>0.05)) in feed intake as in G25 (28.7 kg), G50 (29.3 kg) and G75 (29.7 kg). Most properly that inclusion of big amounts of FBS in rations fed to goat kids has a positive effect on feed consumption relating this to the good flavor and taste and anti-nutritional factors contained in Fava bean.

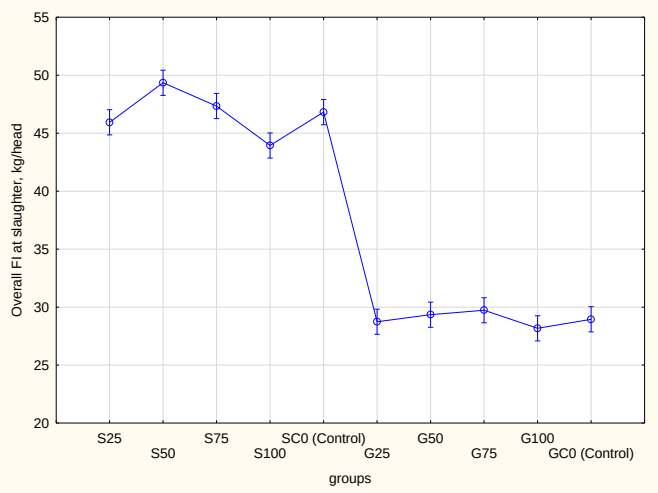

Fig.1. Overall feed Intake (FI, Kg/head)-Lambs Vs Kids

Live body weight (LBW).

Results (Fig. 2) observed at the end of eighth (end of the experiment) weeks showed a significant increase (P<0.05) in average animal weight of S50 group (4.59 Kg) where animals received 50% FBS and 50% SBM in comparison with S100 (29.22 Kg) where animals did not receive SBM in concentrate mix. Moreover, Group S50 recorded the

best body weight increase among all groups. This shows that feeding concentrate mix containing different combinations of SBM: FBS to lambs gives better results than feeding animals with mix containing SBM or FBS alone.

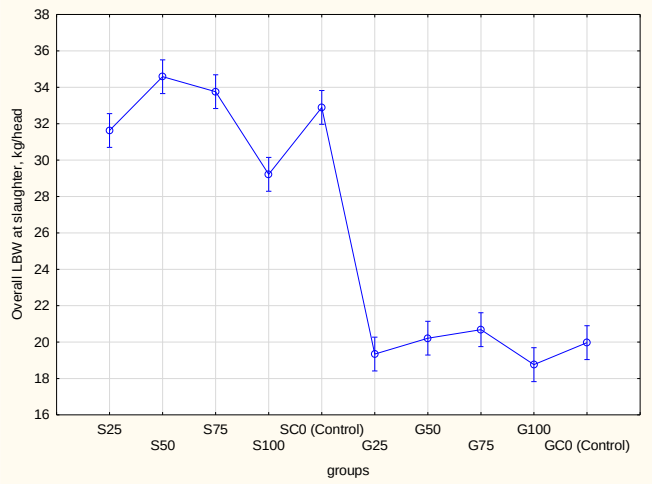

Fig.2. Live body weight at the end of the experiment, Kg/head- Lambs Vs Kids

It was very important to notice from figure 2 that as SBM decreases in combination with FBS higher weights were obtained as in group G75 vs G100 whose animals consumed daily rations without SBM addition.

Despite the fact that Live body weight of kids at the end of the experiment attained the highest level in animal group G75 (20.7 kg/head) but it did not show any significant differences with the remaining animal groups, G25, G50, G100 and GC0 attaining the average/animal 19.34 kg, 20.21, 18.76 and 19.97 kg, respectively (P>0.05). It seems that concentrate mix containing any combination of SBM to FBS has more palatability and at the same time more digestibility in animal digestive tract and consequently in all over nutrient metabolism of the body resulting in higher LBW values. This reflects the fact that neither antinutritional factors nor any toxins found in FBS influenced negatively the absorption of nutrients from the body gastro-intestinal tract from stimulating the animals to gain more weights. It is worthy to point out the fact that great (P<0.05) body weight (32.9 kg) was obtained in animal group SC0 than S100 (29.2 kg) but did not exceed the results (P>0.05) obtained in group S50 (34.6 kg) and S75 (33.8 kg).

Overall live body weight gain (LBWG).

Results show that the overall differences in the overall live body weight gain. Animals of group S50 (50% SBM: 50% FBS) kept in increasing in body weight (P<0.05) where they accumulated 5.8 kg/1st month *Vs* 4.1, 3.2 and 4.8 kg/1st month in groups S25, S100 and SC0, respectively followed by 5.2 kg/1st month in group S75 (P>0.05) . It seems that the best combination used in the experimental ration was in concentrates mix fed to group S50, where the highest results were obtained. This variable for group S50 continued to increase in the same pattern reaching the highest LBWG at the end of the 2nd month where the experiment was terminated attaining the level of 10.9 kg vs 8.5 and 6.5 kg in groups S25 and S100 (P<0.05), respectively and 10.8 and 9.9 kg in groups S75 and SC0 (P>0.05), respectively. As it is shown in Figure 3 animals of group G75 that were fed a ration containing 25% SBM and 75% FBS gained the highest weight (LBWG) at slaughter attaining the level of 5.68 kg in comparison with G100 (P<0.05), G25 (P>0.05), GC0 and G50 (P>0.05) by 3.96 kg, 4.31kg, 5.20 kg and 5.32 kg, respectively.

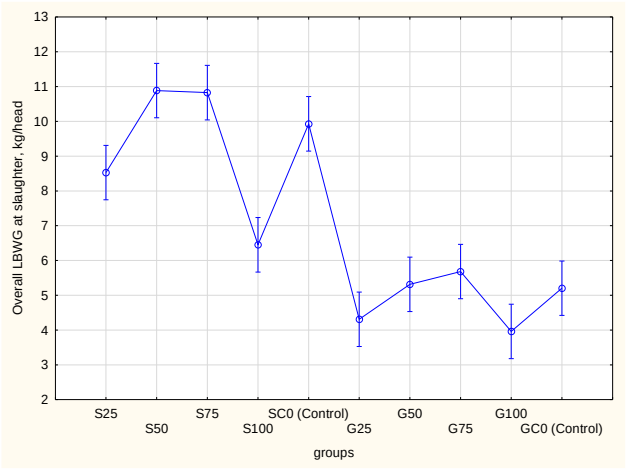

Fig. 3. Overall LBWG, kg/head- Lambs Vs kids

Feed conversion ratio (FCR)

The most negative results accumulated (P<0.05) at the end of the experiment, as shown in figure 4 was in S100 (6.82) in comparison with S25 (5.39) [P>0.05], SC0 (4.74) [P<0.05], S75 (4.39) [P<0.05] and the most efficient S50 (3.92) [P<0.05]. Note that this decrease in the efficiency of feed conversion to meat at the 8th week of the experiment was significantly (P<0.05) greater in group G100 (7.14) than G50, G75 (the most efficient) and SC0 attaining the levels of 5.54, 5.25 and 5.63 respectively. Moreover, results achieved at the end of the experiment in groups G25 (7.68) and G100 (7.13) were almost insignificantly the same (P>0.05).

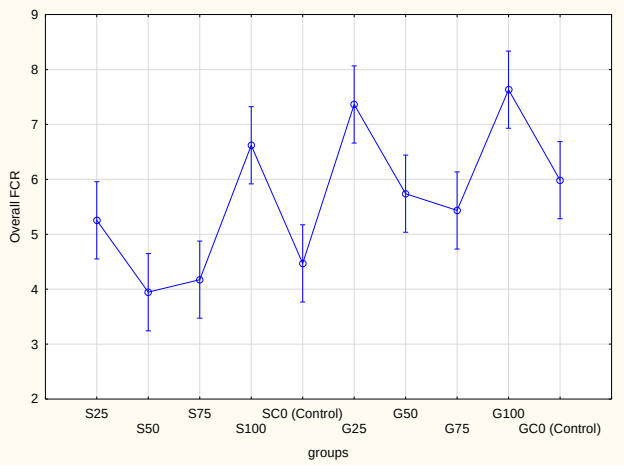

Fig. 4. Overall FCR – Lambs Vs Kids

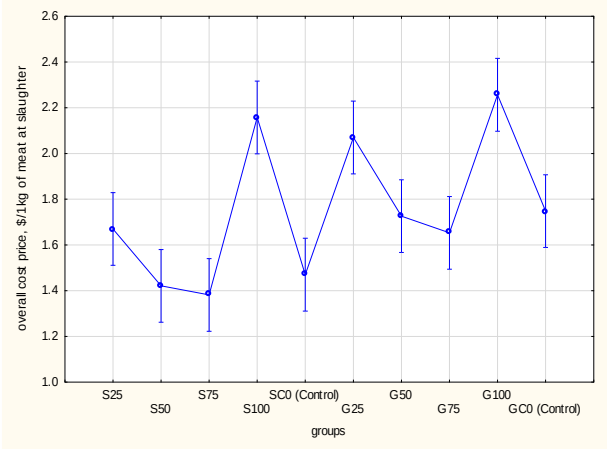

Fig. 5. Overall cost-price ($/1 kg of meat) - Lambs Vs kids

Once more it was shown that rations containing no SBM like in group G100 have negative effect on conversion of rations to meat by eating more feeds and gaining less weight. On the contrast treatment G75 and S50 whose animals were fed rations containing only 25% and 50% of SBM with 75% and 25% FBS has maximum positive effect on conversion of feeds to meat, respectively.

Feasibility study

The results obtained from figure 5 show that feeding FBS with combination with SBM as 50: 50 % as in groups S50 S75, G50 and G75 gave the best and higher results. Moreover feeding FBS (S100 and G100) as the sole legume ingredient did not succeed in giving more profit than other animal groups. Besides feeding rations containing 50 % FBS: 50 % SBM and 75 % FBS: 25 % SBM gave better profit than feeding with 25 % FBS: 75 % SBM. More over, fugure 5 shows the cost price ($) of 1 kg of mutton and goat meat. The most inexpensive meat was recorded for group S75 (1.38 $/1 kg mutton) followed by S50 (1.42), SC0 (1.47), S25 (1.67 $), respectively. The most expensive lamb meat was registered in S100. On the other hand, data obtained from the cost price of 1 kg of meat was higher concerning goat meat where the highest was noted in animal group G100 (2.26 $) followed by G25 (2.07 $). In the same context the lowest was achieved in G75, G50 and GC0 by 1.65 $, 1.73 and 1.75 $, respectively.

Feeding and Growth Performance

The choice of selecting Fava Beans as a replacement for SBM in our experiment agreed with the findings of many researchers as they proposed various species of home-grown grain legumes, such as pea, fava bean, and lupin that represent strategically important alternatives to soybean. They are widely available in Mediterranean areas and increase the sustainability of crop–livestock systems by safeguarding soil fertility and reducing greenhouse gas emissions and use of nitrogen fertilizer (Bonanno *et al.*, 2012; Calabrò *et al.*, 2015). Recently, Calabrò *et al.* (2015) noted in their studies that seed legumes have been regarded as alternatives to soybean as sources of protein in animal feeding owing to disputes about the use of genetically modified organisms (GMOs). In addition, Bonanno *et al.* (2012) considered that legume grains have attracted attention as alternative vegetable protein components for feedstuffs that are used in organic production of meat. The acceptability of fava bean seeds as partial or full replacement for soybean meal in fattening small animals (growing lams and kids) feeds was investigated in this study. Of interest was whether a significant trend in performance would be evident as a result of the changing proportions of soya and fava beans in the experimental feeds, and whether the animals would consume one of the rations excessively in preference to the other. The results suggest that the nutritional quality of the five rations for lambs as well as kids was sufficiently similar in all respects such that performance was the same on all experimental feeds, and neither of the rations was excessively consumed in preference to the other.

Metabolizable energy (ME) value calculated for all rations containing FBS and SBM was almost identical to the analyzed value (2.28-2.96 Mcal/kg). Moreover, the crude protein content of the lambs and kids rations

(~180g/kg) measured in Trials I and II was in good agreement with the values reported by Committee on Animal Nutrition (2007).

Good results were obtained from experiments on Awassi sheep and Sannen kids conducted by Negesse *et al.* (2001), Muruz *et al.* (2017), Burçak and Yalçın, (2018), Yaacoub and Aljammal (2018), Yaacoub *et al.* (2018), Ramos *et al.* (2019) and Yateem *et al.* (2021) in using the same levels of energy and protein in their experiments in comparison with the levels that were used in our trials. In the same context, Surra *et al.* (1992) conducted two experiments on weaned lambs feeding in rations lentils (Vicia ervilia) and faba (Vicia faba) beans were substituted (50% or 100%) for soybean cake in diets for weaned lambs. Substituting fava beans for soybean cake had no effect on performance of lambs.

Feed Intake

Lamb animals of group S50 that consumed ration consisting of 50% FBS and 50% SBM was higher by 7.4%, 4.2%, 12% and 5.4% than that in S25, S75, S100 and SC0, respectively. The highest cumulative feed intake (cFI) at the termination of the experiment was in group S50 (49.35 kg) significantly higher ($P<0.05$) than S100 (43.94 kg). As for kids the overall accumulation of feed intake for the whole period of the experiment was the highest in goat kids group G75 attaining the level of 29.7 kg at the end of the experiment ($P>0.05$). Whereas the daily average of FI for the complete period calibrated between 0.96 kg/head/day for Awassi lambs and 0.59 kg/head/day for Baladi goat kids.

Once more, this might be related to the fact that rations fed to animal-group G100 did not contain SBM and only 100 % FBS making the consumption of rations for goats lower than any other legume-ingredients combination. As SBM decreases and FBS increases in rations we observe an increase ($P>0.05$)) in feed intake. Most properly that inclusion of big amounts of FBS in rations fed to goat kids has a positive effect on feed consumption relating this to the good flavor and taste and anti-nutritional factors contained in Fava bean. Generally, the type of dietary legume supplementation has no effect on growth, animal health and feed palatability in both lambs and kids as well, where no health anomalies or malnutrition were noticed. Whereas no left behind concentrated mix was collected in all over the period of the two trials.

In the present experiment feed intake in both trials increased linearly with fava bean inclusion, suggesting that the animals needed to consume more of this ingredient to meet their nutrient requirements in energy and protein. Similarly, feed intake is unlikely to increase with fava bean content, as it did in our trials, if there is a toxin present in the fava beans. Giovanni (1984), Surra *et al.* (1992) and Massimiliano *et al.* (1999), observed the same increase in concentrates intake containing Fava bean. The latter suggested that the level and activity of anti-nutritive factors in Fava bean, mainly tannins, have less effect on ruminants than monogastric animals.

In reference, our achieved results coincides with the findings of Surra *et al.* (1992), Caballero *et al.*, 1992, El Maadoudi (2004), Delmotte and Rampanelli (2006) and Lanza *et al.* (1999, 2007, 2011) noting that fava bean is highly palatable for domastic small ruminants, which prefer it to barley. In growing lambs and fattening sheep and goats, including fava beans in isoprotein and isoenergetic diets in substitution for soybean meal did not affect intake, performance and digestibility. They also added that in lambs, including fava beans up to 50% in the diet did not affect meat quality when compared to soybean meal. The use of a diet based largely on fava bean for fattening lambs resulted in growth and meat characteristics similar to the most frequently used diets containing soybean meal as the main source of protein.

Nevertheless, all the results obtained from our research confirmed the findings of Kung *et al.* (1991), Murphy & McNiven (1994), Stanford *et al.* (1996), Vicenti *et al.* (2009), Facciolongo *et al.* (2014, 2015), Lestingi *et al.* (2015a, 2015b, 2016), Yaacoub and AlJammal (2018) and Yaacoub *et al.* (2018). In their earlier studies, they confirm the use of diets that incorporated fava bean, alone and in mixtures, as alternative protein sources to soybean in feeding for fattening lambs and kids that did not negatively affect the in vivo performances or carcass yield and quality. The absence of negative effects on intake, growth, and carcass quality, when replacing SBM with fava beans, support the results of previous studies with Simmental bulls fed a maize-silage based diet (Keller *et al.*, 2021) and Marchigiana bulls fed a diet with >550 g concentrate/kg total diet DM (Cutrignelli *et al.*, 2008a; 2008b).

Live body weight (LBW) and Live body weight gain (LBWG)

Overall, average weekly gain for lambs and kids (around 172 and 107 g/day/head, respectively) was substantially comparable with the one found in similar previous experiments (Caballero *et al.* 1992; Lanza *et al.* 2003b; Loe *et al.* 2004). In addition, carcass weights at the end of the trials were not affected by dietary treatments. The average values attained for lambs the levels of 32.4 and kids 19.8 kg/head) were higher compared to those (<17 kg) reported in previous similar experiments where these

differences can be probably attributed to different slaughter ages (Lanza *et al.*, 2007). More over, Loe *et al.* (2004) did not observe significant differences in carcass weights from lambs fed diets with different peas proportions as well as Surra *et al.* (1992) and Purroy *et al.* (1992) between lambs fed diets including different proportions of fava bean and those fed soybean meal-based diets. Carcass classification according to European regulations showed favorable acceptability by local markets with medium fat coverage and good or optimal muscular conformation. Diets with alternative legume seeds, such as peas and fava bean, did not adversely affect growth performance compared to soybean meal diet. Difference in the initial LBW between Awassi lambs and Baladi kid goats was related to the difference in species where, Baladi kids (14.9 ± 0.259 kg) were lower in LBW than Awassi lambs (23.1 ± 0.52 kg) of the same age. Despite this fact feed intake was significantly ($P<0.05$) correlated ($r =1$) to LBW taking into consideration the size of the animal. Distribution of all animals were equal ($P>0.05$) in live body weight in reference to the species used (Sheep and goats). In agreement, Cutrignelli *et al.* (2008a, 2008b) observed a lower live body weight (LBW) at an earlier fattening period for animals fed fava beans instead of SBM, possibly due to limited rumen undergraded protein (RUP) supply. However, in the present study, significant differences were found in growth performance at earlier growing periods and continued to the end of the trial especially in S100 and G100 (100% FBS) Vs S50 and G50 (50% FBS: 50% SBM) and S75 and G75 (75% FBS :25% SBM). This fact revealed that, fava beans in appropriate combination with SBM seem to be an applicable replacement for SBM in the diets of fattening sheep and goats. Even though S50 showed, an intensive decrease in weekly live body weight gain (waLBWG) from week one to week three, where it continued until week six, we noticed better absolute average live weights at the end of the experiment. No explanation was found to clarify this phenomenon; a combination of soybean meal and fava seed meal fed together with daily rations gives better results. Whereas feeding solely SBM or FBS result in lighter weights and minimum body weight gains.

Once more results show that a combination of soybean meal and fava seed meal fed together with daily rations gives better results. Whereas feeding solely SBM or FBS result in lighter weights and minimum body weight gain.

The cumulative live body weight gain (cLBWG) initiated with the end of the 1st week increased from week to week attaining the highest score after one week of the initiation of the experiment to increase ($P<0.05$) by 1.6 kg/week in group S50 *Vs* 0.9 kg/week, 1.2, 0.7 and 1.2 kg/week in groups S25, S75, S100 and SC0, respectively. Animals of group S50 (50% SBM: 50% FBS) kept in increasing in body weight ($P<0.05$) where they accumulated 5.8 kg/1st month *Vs* 4.1, 3.2 and 4.8 kg/1st month in groups S25, S100 and SC0, respectively followed by 5.2 kg/1st month in group S75 ($P>0.05$). It seems that the best combination used in the experimental ration was in concentrates mix fed to group S50, where the highest results were obtained. This variable for group S50 continued to increase in the same pattern reaching the highest cLBWG at the end of the 2nd month where the experiment was terminated attaining the level of 10.9 kg vs. 8.5 and 6.5 kg in groups S25 and S100, respectively and 10.8 and 9.9 kg in groups S75 and SC0 ($P>0.05$), respectively. Animals of group G75 that were fed a ration containing 25% SBM and 75% FBS gained the highest cumulative weight gain (cLBWG) at the end of the trial attaining the level of 5.68 kg in comparison with G100 and G25 ($P<0.05$), GC0 and G50 ($P>0.05$) by 3.96 kg, 4.31kg, 5.20 kg and 5.32 kg, respectively. The best results on weekly live body weight gain (wLBWG), were achieved in G75 and the least in G100 at the end of the termination of the trial ($P<0.05$).

Importantly, experimental concentrates applied in the present study were always completely consumed by the animals, indicating a high palatability of these concentrates independent of protein source. Loe *et al.* (2004) noted that diets with alternative legume seeds, such as peas and fava bean, did not adversely affect growth performance compared to soybean meal diet. Our results obtained were in contrast with the findings achieved by Caballero *et al.* (1992) who stated that the use of a lamb fattening diet largely based on fava bean gave similar growth performance and meat characteristics compared to the traditional diets based on soybean meal as main protein source.

Antongiovanni *et al.* (2002), Martinez *et al.* (2004) and Morbidini *et al.* (2005) obtained results similar to ours on young growing lambs fed fava bean seeds (50-60% of the diet) as the sole protein source in concentrate mix increased daily weight gain demonstrating the already high protein value of fava beans for growing lambs. Duke (1981) suggested the fact that to reduce reliance on imported soybean meal (SBM) in temperate environments, fava bean may be alternative protein sources for small ruminant diets. Fava bean is used as an important source of protein rich food in developing countries and as both food and feed for animals in industrialized countries. Edwards (2004) showed that, tannins present in the seed coat of fava beans have limited effect on broilers, pigs or ruminants. The trypsin inhibitor activity in fava beans is not well documented but appears to be low. In agreement to what

was proposed by Liener (1976), Dvořák *et al.* (2006) and Esenwah and Ikenebomeh (2008) that stated that the nutritional value of leguminous proteins might be limited by the presence of antinutritional factors. The protease inhibitors, trypsin and chymotrypsin, are perhaps the most widely distributed of all antinutritional factors in legumes. Monogastrics are thought to be more susceptible to the effects of antinutritional factors than ruminants. In fact, for ruminants, trypsin inhibitors are not considered important (McDonald *et al.*, 1973). In contrast to Cerioli *et al.* (1998) who concluded that, beans have a lower content of trypsin inhibitors than the soybean and can be used as proposed by Matthews and Marcellos (2003) in dairy rations at inclusion levels of up to 35%.

Feed conversion ratio (FCR)

The highest values (inefficient) in body retention of lambs per week (wFCR) were observed in animal group fed 100% FBS (S100) that calibrated between 60.3% at the end of the 1st and 40.3% by the end of the 8th week in comparison with results obtained in animal group fed 100 % SBM (SC0). This can be explained, by consuming more feeds to convert them to body weight gain and at the same time getting less live body weights due maybe to the overall effect of antinutritional factors found in fava bean seeds which was included as a sole legume ingredient (100% FBS) in ration. Moreover, results that are more efficient were achieved in groups S50 and S75 whose animals were fed a combination of SBM: FBS in different proportions. If to compare the overall average results among lamb groups for the whole period we observe that wFCR in group S75 (4.36) was less than what was obtained in groups SC0 (4.67), S50 (4.71), S25 (5.31) and S100 (6.89). Nevertheless, lambs of group S100 inefficiently converted feeds into body weight gain than animals of other groups. It was noticed that from the end of the 1st week wFCR in S100 was inefficiently ($P<0.05$) higher (6.71) than groups S50 (3.31), SC0 (4.17), S75 (4.01) and S25 (5.34) as well ($P>0.05$). This can be explained by the findings reported by Miller (1980) that fava bean protein is highly soluble in the rumen. Whereas, Emiola and Gous (2011) agreed that Fava bean feeding at various levels did not affect digestibility. However, Fulpagare (1993) reported that as the level of fava bean increase (from 25 to 100%) in the diet of lambs, the digestibility of dry matter (Ether extract and crude fiber) increase, while that of nitrogen-free extracts (NFE) decreases. The best results accumulated ($P<0.05$) at the end of the experiment for lambs was in S75 (4.39) followed by S100 (6.82), S25 (5.39), SC0 (4.74), and the most efficient was S50 (3.92).

Once more it was shown that rations containing no SBM like in group G100 have negative effect on conversion of rations to meat by consuming more feeds and gaining less weight. On the contrast treatment G75 whose animals were fed rations containing only 25% of SBM with 75%, FBS has maximum positive effect on conversion of feeds to meat. This can be explained by the findings reported by Miller (1980) that fava bean protein is highly soluble in the rumen. Whereas, Emiola and Gous (2011) agreed that Fava bean feeding at various levels did not affect digestibility. However, Fulpagare (1993) reported that as the level of fava bean increase (from 25 to 100%) in the diet of animals, the digestibility of dry matter (Ether extract and crude fiber) increase, while that of nitrogen-free extracts (NFE) decreases.

Although in the trial conducted by Brand *et al.* (1995) performance was not reduced when fava beans were included at 0.2 kg of the diet, which was in contrast with our findings. Nevertheless, Results obtained by Abbey *et al.*, 1979; Guillaume, 1977; Rubio *et al.*, 1990; Reddy *et al.*, 1985; Marquardt, 1989; Wiseman & Cole, 1988; Jansman *et al.*, 1995 and Knox *et al.*, 1995) were in agreement with our findings. Where performance has been reduced by the inclusion of fava beans this has been attributed to the content of condensed tannins and non-starch polysaccharides (NSP) in the seeds.

Thus, the development of untraditional protein crops may be a solution to improve the valorization of products and forage grown on the farm. Among alternative protein sources to soybean, lupine and pea seeds have been successfully used in diets for dairy cows in European and American countries (Murphy *et al.* 1987). In addition to these legumes, field beans (FB, *Vicia faba* L.) could represent another interesting alternative, as recently suggested by Volpelli *et al.* (2010) in a study with dairy cows fed organic diets.

IV. CONCLUSION

In summary, the 50: 50 and 75: 25 proportion of FBS: SBM improved bofy performancr profile compared to values reported for conventional fattening diets, without additional metabolizable protein-concentrate supplementation.

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The effect of replacing soybean meal with Fava bean seeds in daily ration of Lebanese Baladi goat kids and Awassi sheep lambs: 2- Meat quality

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Abstract— *The objective of this study was the physical characterization of the qualitative traits of meat acquired from different small ruminant species. Local Baladi goat male kids and Awassi male lambs fed basal commercial ration supplemented with different proportions of fava bean seeds (FBS) and soybean meal (SBM). Upon reaching about 7 months of age the experimental animals were slaughtered and samples of muscle tissue were collected to be analyzed. Definitely, meat samples were exposed to evaluations of the physical parameters, including pH, color, water retention and meat texture. Physical quality of meat did not differ much among groups. pH indicator after 7 days of freezing was more acidic for both types of meat. Nevertheless, goat meat was more consistent in being more acidic than mutton calibrating from 6.22 as in GC0 group to 6.29 in G25 (P>0.05). Moreover, if to compare meat obtained from animals fed 25% FBS in daily ration we notice less acidity than other groups attaining the levels of 6.37 and 6.29 in groups S25 and G25, respectively (P>0.05). It shows that after cooling results of L* are higher than those obtained after freezing in all animal-groups of both sheep and goats. Lighter in color meat L* on 0-100 scale was scored in groups consuming the highest proportion of SBM: GC0, SC0, G25 and S25s, where it attained the levels of 54.90, 54.54, 54.41 and 55.64, respectively. The highest redness (a*) of goat meat was achieved in GC0- animal group whose kids were fed rations with 100 % SBM attaining the level of 21.09 (P>0.05) in comparison with all other groups. Although redness in G100 was the lowest (7.75) before freezing, we notice that after freezing this indicator was the highest in this group (13.08) when compared with all experimental animal groups (P>0.05): GC0 (11.20), G75 (8.89), G50 (7.46) and G25 (6.89) in the results obtained for after freezing in animal group. Better results for redness (a*) were achieved in animal groups GC0 (100 % SBM) before freezing at 24 h post-mortem and SCO (100 % FBS) after 7 days of freezing in meat of goat and sheep as well, attaining 21.09, 20.75, 13.08 and 13.91, respectively (P>0.05). In comparing the data obtained yellowness (b*) between goat and sheep meat before and after freezing shows that the highest level of b* was achieved in goat meat in group G75 before (19.08) and after (16.31) freezing (P>0.05) and GC0 (11) after freezing (P<0.05). Even though yellowness before freezing was high in both species it was observed that this indicator decreases after freezing on much higher rates in mutton than goat meat (P>0.05). It is worthy to mention that SC0 and GC0 attained statistically significant (P<0.05) higher level of drip loss in meat water after 24 h of cooling in comparison with all animal groups except S25 and G25 where this decrease was insignificant (P>0.05). Thawing loss (%) in sheep was higher than that obtained in goat meat when comparing each two different animal groups fed with the same ingredients as in S25 and G25, S50 and G50, S75 and G75 and S100 and G100, SC0 and GC0 (P>0.05). The highest values (P>0.05) were in groups SC0 (12.21 %) and GC0*

(10.93 %) and the lowest in S25 (7.22 %) and G25 (5.80 %). The least cooking losses in water was registered in S50, S25, S100, S75 and SC0 losing weight after cooking averaging to 26.18% Vs 11.09%, 27.54 Vs 11.96, 28.25 Vs 12.28, 32.47 Vs 14.27 and 33.15 Vs 13.09% in both conditions, 24 h Vs 7 days, respectively (P<0.05). The lowest level (6.90 mm) of tenderness of goat meat was noticed in group G50 (P>0.05) after cooking after 7 days of freezing whose animals were fed rations containing equal proportions of SBM: FBS (50: 50) next to G75 (7.14 mm), G100 (7.40 mm) and GC0 (7.45 mm). Whereas this trait after 24 h for sheep the lowest was obtained in group SC0 (2.06 mm) in comparison with all other groups, S100, S50, S25 and S75 attaining the levels of 2.08, 2.36, 2.47 and 2.87 mm, respectively (P>0.05). Note that all levels obtained in all goat groups after cooking after 7 of freezing days were significantly higher (P<0.05) meaning tender than those from sheep meat after freezing and 24 h of cooling in groups S25 (3.51 mm), S50 (2.50 mm), S75 (5.47 mm), S100 (4.27 mm) and SC0 (2.59).

Keywords— ***Soybean meal, fava bean seeds, Awassi lambs, goat kids, physical quality of meat.***

I. INTRODUCTION

The need for alternative protein sources to soybean meal (SBM) in domestic animal feeding has recently gained focus. The main reasons include the attempt to limit SBM import from extra-EU Countries, which represents a negative voice of the commercial balance. An effort to decrease costs of animal production and contemporarily reduce the loss of N-compounds in the environment and the search to prevent the presence of GMO (Genetically modified foods) in the food chain (Wilkins and Jones, 2000; Mordenti and De Castro, 2005; Formigoni *et al.*, 2007). Among the possible protein sources, lupins, peas and fava beans *(Vicia fava L.)* were successfully used in ruminants and nonruminants (Burel *et al.,* 2000; Bonomi, 2005; Moschini *et al.,* 2005; Masoero *et al.*, 2006; Vandoni *et al.,* 2007; Keller *et al.*, 2021). Demand for pulses for stock feed both locally and in export markets is likely to have a major influence on prices. Pulses are valuable stock feeds because of their high protein levels and palatability (Henchion *et al.*, 2017). They can be used as part of intensive livestock rations or as supplements for stall reared stock. In some countries lupines are generally the preferred pulse for sheep and cattle because of their higher protein, higher fiber and lower starch levels, but peas and fava beans (FBS) are also useful and are commonly used overseas (Zagorakis *et al.*, 2018a). Pulses are used in intensive rations to provide energy and essential amino acids for growth (Beigh *et al.,* 2017; Poutanen *et al.,* 2022).

Small ruminant's production contributes to the livelihoods of a large number of farmers and accounts for 28-58 % of agricultural output in the Middle East (Iniguez, 2005). In Lebanon small farmers in marginal lands, where milk constitute an important source of income (Hosri and El khoury, 2004; De Rancourt *et al*., 2006; Hosri *et al*., 2016), mainly conduct it. Awassi lamb-fattening and goat-fattening systems in Middle Eastern countries are popular because they can rapidly generate income. Nevertheless, feed costs constraining these systems and seasonal fluctuations in feed prices expose farmers to risk. Despite the important relative size of the small ruminant's flock in Lebanon (330000 head of sheep and 450000 head of goats (FAO, 2010), the sector is facing many difficulties.

The outbreak of BSE in the 1990s caused proteins of animal product to be banned as feed, but now it will be permitted for non-ruminants (Minchin, 2021). A large integrated Project called "Grain Legumes" is combining the efforts of scientists from 18 countries in order to make legume crops more competitive for European agriculture, using the latest progress in genomics and ranging from plant improvement and crop management to feed processing. Existing protein sources are primarily hindered by their negative environmental impacts with some concerns around health. However, they offer social and economic benefits, and have a high level of consumer acceptance (Henchion *et al.*, 2017; Małecki *et al.*, 2021)

Duc (1997), Haciseferogullari *et al.* (2003), Hossain and Mortuza (2006), Crepon *et al.* (2010), Yah Konfor (2013) and Mayer Labba *et al.* (2021) published that the nutritional value of fava bean has always been traditionally attributed to its high protein content, which ranges from 27 to 34% depending on genotypes, Oil, 1.2 g; Crude Fiber, 5.1 g; Starch, 51 %; Sugars, 5 %; Iron, 4.2 mg; Thiamin, 0.45 mg; Riboflavin, 0.19 mg; Niacin, 2.4 mg; Energy, 328 kcal. Most of these proteins comprise of globulins (79%), albumins (7%) and glutelins (6%). In addition, Berrazaga *et al.* (2019) found that the nutritional value of fava bean was 87 and 31% for DM and CP, respectively. Legume seeds contain several comparatively minor proteins including trypsin inhibitors, lectins, lipoxygenase and urease, which are relevant to the nutritional quality of the seed (Bartsch and Valentine, 1986; Halmemies-Beauchet-Filleau *et al*., 2018).

Hanbury *et al.* (2000), Yin *et al.* (2011), Watson *et al.* (2017), Yaacoub and AlJammal (2018), Yaacoub *et al*. (2018), Halmemies-Beauchet-Filleau *et al.* (2018),

Lestingi *et al.* (2019), Ibáñez *et al.* (2020) and Parisi *et al.* (2020) reported that, to reduce reliance on imported soybean meal (SBM) in temperate environments, fava bean might be alternative protein sources for small ruminant diets. Surra *et al.* (1992), El Maadoudi (2004), Delmotte and Rampanelli (2006) noted that Fava bean is highly palatable for lambs, which prefer it to barley. In lambs, including fava beans up to 50% in the diet did not affect meat quality when compared to soybean meal (Antongiovanni *et al.*, 2002; Lanza *et al.*, 2007; Emiola and Gous, 2011). Mullan (2001), FAO (2002), Connell *et al.* (2004), Mukherjee *et al.* (2016), Sedláková *et al.* (2016), Addisu (2016), Shi *et al.* (2017), Naumann *et al.* (2017), Choi *et al.* (2019), Samtiya *et al.* (2020), Te Pas *et al.* (2021), Mazumder *et al.* (2021), Mayer Labba *et al.* (2021) and Landi *et al.* (2021) stated that bean, chickpeas and lupine cultivars grown in most countries of the World tend to have now low tannin, vicine and covicine in their seed coats. Cerioli *et al.* (1998) and Shi *et al.* (2017) concluded that the bean has a lower content of trypsin inhibitors than the soybean and no urease activity but contains more tannins. Aplocina and Veipa (2015) reported that fava beans could be used in dairy rations at inclusion levels of up to 35%.

To our knowledge, the present study is among the firsts to focus on the effect of feeding FBS (fava beans) on physical quality in Lebanese local *"Baladi"* goat and Awassi sheep breeds in fattening production. Therefore, data on the effect of FBS on meat quality of locally reared small ruminants are scarce.

The aim of our experiment was to evaluate the influence of replacing totally or partially soybean meal with fava beans in rations fed to weaned lambs and kids of local Awassi sheep and local goat breeds (*Baladi*) on some physical traits of meat.

II. METHODOLOGY

This experiment was implemented on two commercial farms situated in different districts of Lebanon (Bekaa for sheep and Akkar for goats). No big differences in ambient temperature and relative humidity between the two locations was registered.The nimals were controlled in agreement with the national legislation on animal welfare (Council Directive, 2008/119/EC) and slaughtered in amenability with the European Council Regulation No 1099/2009 (Council Regulation, EC, 2009).

In this experiment were randomely selected and used fifteen male Awassi lambs (S) and fifteen male Baladi goat kids (G) at about 100 days of age. Until the time of slaughter, every three animals were housed in seperated sheds equipped with collective drinking and feeding troughs. Concerning the experimental rations, every day each animal group fed a combination (1: 1) of alfalfa hay and wheat straw *ad libitum* with no more than 1 kg/head/day (depending on live body weight at the beginning of each week of the experiment) of a concentrate mix whose structure is reported in Table 1.

At the beginning of the trial and with the initiation of the preparatory period, (2 weeks) animals were dipped and treated for all kinds of helmentic worms. Besides, they were ear tagged and vaccinated against Anthrax and FMD; Albendazole was administered with drinking water as prevention for digestive tract parasites. Veterinary inspection was repeated every week where intramuscular injections of multivitamin dozes (A, D & E) were administered. The animals were in good health (veterinary examination).

Refused feeds (what was left behind in the feeding troughs) from each pen if existeded were collected, weighed and recorded each week in the morning before the start of group feeding. The trial proceeded for 8 weeks (collection of samples for analyses).

Table 1. Experimental concentrate-rations composition (percentage as fed basis) fed to lambs and kids

Animal groups	[1]S25/G25	[2]S50/G50	[3]S75/G75	[4]S100/G100	[5]SC0/GC0 (Control)
Ingredients	75% SBM+ 25% FBS	50% SBM+ 50% FBS	25% SBM+ 75% FBS	100% FBS+ 0% SBM	100% SBM+ 0% FBS
SBM	11.1	7.4	3.7	0.0	14.8
CSM	7.4	10.0	13.0	15.8	5.1
FBS	3.7	7.4	11.1	14.8	0.0
Wheat bran	16.0	15.0	12.7	12.3	14.7
corn	61.7	60.1	59.4	57.1	65.4

Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
CP	**17.9**	**18.0**	**17.9**	**17.9**	**18.0**
ME Mcal/kg	**2.85**	**2.52**	**2.94**	**2.28**	**2.96**

[1]Experimental groups - S25 (Sheep) & G25 (Goat) where FBS partially replaceing 25% of the SBM is added to the basal ration (25% FBS: 75% SBM). [2]Experimental groups - S50 (Sheep) & G50 (Goat) where FBS partially replacing 50% of the SBM is added to the basal ration (50% FBS: 50% SBM).[3]Experimental groups - S75 (Sheep) & G75 (Goat) where FBS partially replacing 75% of the SBM is added to the basal ration (75% FBS: 25% SBM). [4]Experimental groups - S100 (Sheep) & G100 (Goat) where FBS totally replacing 100% of the SBM is added to the basal ration (100% FBS: 0% SBM). [5]Experimental control groups - SC0 (Sheep) & GC0 (Goat) where this control ration was composed of 100 % SBM and no inclusion of FBS supplementing the basal ration (0% FBS: 100% SBM). In addition, this ration represents commercial feeding in fattening lambs and kids used at the Lebanese farms following the indoor keeping system.

All rations were isocaloric (2.9 Kcal/kg ME) and adjusted to the same level of crude protein (17%) as recommended by NRC (1989) and based on cotton seed meal (CSM), wheat bran and corn, fed continuously with different levels of Soybean meal (SBM) : Dry milled Fava bean seeds (FBS) for the whole experimental period.

Physical analysis of meat quality

At about 7 months of age, the experimental animals were managed in a commercial slaughterhouse. All internal organs were inspected by veterinary specialists to inspect (if any) any symptoms of illness or malnutrition. Each carcass was divided in half covered with a film during storage and conserved at a controlled temperature of 4°C. Samples of muscle tissue were taken immediately *postmortem* from the *longissimus dorsi* between the 12th and 13th ribs from the left side of the carcasses were collected after skinning and eviscerating and packed after immediate weighing by 100g in 2 polyethylene sheets. One of the two sheets was stored in refrigerators for 24 hours of cooling at 4°C - 5°C while the other polyethylene sheet was stored below -27ºC to freeze for 7 days.

Evaluation of pH, color and meat tenderness

At 24h (hours) *postmortem* and 7 days of freezing muscle slices of 2 g each were removed from each polyethylene envelop and immediately homogenized in 18 ml of 5 mM iodoacetate buffer (Jeacocke, 1977). The pH of the homogenate was measured using a portable pH meter (HI 8424 Microprocessor pH Meter, HANNA Instruments, Woonsocket, RI.) equipped with a combined electrode.

There are many options available for instrumental color analysis, however; according to Stevenson *et al.* (1991), the CIELab color space (Robertson, 1977), expressing color by the coordinates L*, a* and b*, are appropriate color measures. Lightness in meat color is represented by L* on a scale from 0 to 100, where 100 corresponds to pure white and 0 corresponds to pure black. A negative a* value indicates greenness and a positive a* value represents redness. A positive b* value indicates yellowness, while a negative b* value corresponds with blueness. At 24 hours, *postmortem* of cooling and 7 days of freezing, meat color was determined using a chromameter (ADCI - 60 - C). The instrument was set to measure using the CIE system (International Commission on Illumination; abbreviated CIE for its French name) values of luminance (L*), redness (a*), and yellowness (b*) using illuminate D and 65° standard observer (Robertson, 1977). All measurements (3 replicates on each 3-cm thick muscle slices) were carried out on the surface of the left muscle slice, in an area free of obvious color defects (over scalding, blood spots, and hemorrhages) using a Chromometer (ADCI-60-C; Beijing Chentaike Instrument Technology, CO, LTD) calibrated to a standard white tile.

Cooked meat tenderness was measured using a penetrometer (interface RS232C) with a needle of 2.5g on a weight of 47.5 g, thus attaining a total weight of 50 g. The penetration was carried out on meat slices (3 x 2 x 1 cm) prepared in a way the longest dimension was parallel to the fiber axis. The slices were placed on a horizontal support and a force of the needle was applied perpendicularly to the muscle fibers for 5 seconds (Becila, 2002). The penetrometer needle depth (PND), mm) was recorded (in mm) and calculated as the average of 3 replications of each sample. The procedure was conducted on cooked meat after 24 hours of cooling and after cooking after 7 days of freezing.

Drip loss (DL, %), Thawing loss (TL, %) and cooking loss (CL, %)

Drip loss was determined by the method of Offer and Knight (1988). Left raw muscle slices were weighed after cooling at 24 hours post-mortem, placed in a polystyrene

tray, wrapped in an oxygen permeable film and kept at 5-7°C for the 2nd day. Slices were reweighed at 48 hours *postmortem* and the drip loss was expressed as percentage of initial weight. After 12 hours thawing in a refrigerator at 5-7°C, Muscle slices were taken from bags, dried with filter paper, and reweighed before cooking. Thawing loss was expressed as a percentage of the frozen weight (Honikel, 1998). Cooking loss was determined immediately after cooling and thawing in meat samples vacuum packed in polyethylene bags and cooked in a water bath at 80°C for 15 minutes (corresponding to an internal temperature of 70°C (Honikel, 1998). Care was taken to ensure that all samples were of similar dimensions. Samples were chilled for 45 minutes under running tap water at room temperature. After that, they were taken from the bags, dried with filter paper and weighed. Cooking loss was expressed as the percentage loss relative to the weight immediately before cooking. Cooking loss was determined by weighing a 1.0- 1.5 cm thick sample and placing the raw meat in a plastic bag in a pre-heated water bath (80°C) for 1h (Cloete *et al*., 2005). The cooked meat sample was removed after 1h from the water bath and placed in a cooler for 24h at 4°C. Samples were blotted with tissue paper to remove the excess water before the final weight was recorded. The weight loss of each sample was expressed as a %-age of the initial weight of the raw sample.

Statistical analysis

Data were analyzed using the analysis of variance (ANOVA) procedure (Statistica, 2020). The experimental design was a randomized block design, with three replicates per treatment (3 x 5). Analysis of variance techniques were used to assess the statistical significance ($P<0.05$) of treatment effects. Feed intake (FI) and food conversion ratios (FCR) in each animal group were analyzed as apparent feed intake (aFI/head) and apparent feed conversion ratio (aFCR/head). Interaction and comparison among means was tested using the All-Pair wise Multiple Comparison Procedures (Bonferroni test method) at a level of 5% significance. Mean ± SD (Mean values of the traits ± Standard Deviation) is used in all obtained statistical studies.

III. RESULTS

Physical properties of goat and lamb meat

pH indicator

The comparison performed in pH indicator of meat between goat and lamb muscle tissue samples (Fig. 1) did not highlight significant differences ($P>0.05$) regarding pH level after 24h *postmortem* and 7 days of freezing in both types of meat. Nevertheless goat meat was more consistent in being more acidic than mutton calibrating from 6.22 as in GC0 group to 6.29 ($P>0.05$). Moreover if to compare meat obtained from animals fed 25% FBS in daily ration we notice less acidity than other groups attaining the levels of 6.37 and 6.29 in groups S25 and G25, respectively ($P>0.05$).

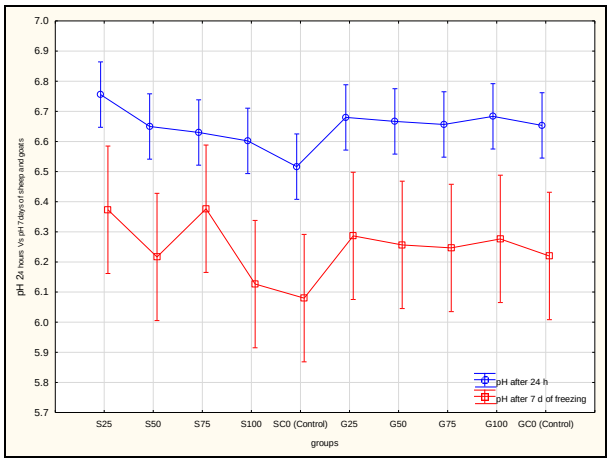

Fig.1. pH indicators after 24 hours postmortem Vs. 7 days of freezing among all groups of mutton and goat meat

Color

The characteristic color is a function of two factors: the meat pigments and the light-scattering properties (Miller, 1994; Gómez *et al*., 2019).

Luminosity (L)

Figure 2 shows the results obtained after testing Luminosity (L) using the Chromometer of goat meat before and after 7 days of freezing. It was noticed that there is no significant differences before ($P>0.05$) or after ($P>0.05$) freezing in goat meat among all samples in all animal groups. Nevertheless, it is worthy to mention that raw meat samples taken from the loin eye of animals of G100 animal group were lighter in color (51.03) on 0 – 100 scale measurement followed by G75 (50.67). Data in figure 2 shows that after cooling results of L* are higher than those obtained after freezing in all animal-groups of both sheep and goats. Lighter in color meat L* on 0-100 scale was scored in groups consuming the highest proportion of SBM: GC0, SC0, G25 and S25s, where it attained the levels of 54.90, 54.54, 54.41 and 55.64, respectively. Even though meat quality was darker at 24 h *postmortem* in all animal groups of both species if compared to that data achieved after freezing, we notice that the lowest levels (darkest color of meat) were attained in sheep in group S25 (40.34) whereas the lightest (lighter color of meat) scores was obtained ($P<0.05$) in G100 (51.02) and G75 (50.67).

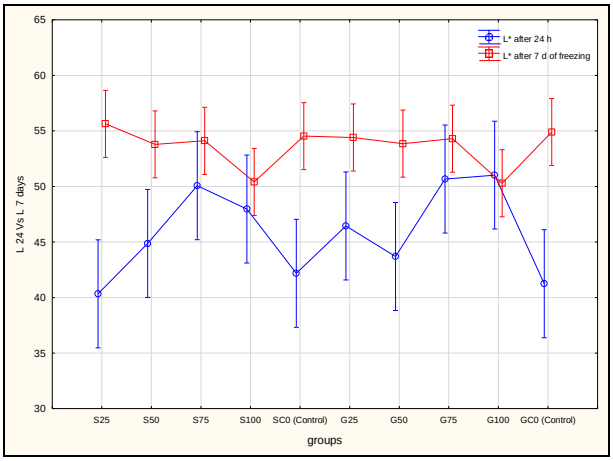

Fig.2. Comparison of luminosity L between Goat and sheep Meat.*

Data obtained from figure 2 on raw goat meat before freezing at 24 h post-mortem shows that as the %age of SBM increases in rations as in G50- 50 % SBM, G75- 75% SBM and GC0- 100% SBM) meat color (L) becomes relatively darker (P>0.05). In contrast to what was observed in before freezing, the after freezing Chromometer tests show that as the %age of SBM increases in rations, lighter (L) in color meat was obtained. The highest score was observed in group GC0 attaining the level (P>0.05) of 54.9 (100 % SBM) Vs G100 with 50.29 (100 % FBS). Moreover Figure 2 shows that raw meat before freezing taken from animal-groups fed SC0 ration containing 100 % SBM followed by S25 with 75 % SBM : 25 % FBS were insignificantly (P>0.05) darker than S50 (44.88), S75 (50.07, P<0.05) and S100 (47.97). Even though this tendency was seen in after freezing results it was statistically insignificant (P>0.05). The highest scores were attained in groups S25 (55.64) and SC0 (54.54) and GC0 (55.1).

Redness (a)

Statistically non-significant results are shown in Figure 3 in measuring the redness of goat meat before freezing. The highest redness (a*) of goat meat was achieved in GC0-animal group whose kids were fed rations with 100 % SBM attaining the level of 21.09 (P>0.05) in comparison with all other groups. Although redness in G100 was the lowest (7.75) before freezing, we notice that after freezing this indicator was the highest in this group (13.08) when compared with all experimental animal groups (P>0.05): GC0 (11.20), G75 (8.89), G50 (7.46) and G25 (6.89) in the results obtained for after freezing in animal group.

Note that there is a tendency of reducing the red color of goat meat after freezing as the concentration (%) of SBM increases in the ration to attain the highest level in group G100 with 0 % SBM.

Figure 3 shows the results obtained after testing for sheep meat redness (a*). The same tendency in this trait was shown also in sheep meat (mutton) after freezing revealing the fact that as %age (%) of FBS portion increases in rations fed to Awassi lambs redness goes up attaining the highest score (13.91) in group S100 whose animals were fed 100 % FBS in concentrate mixture followed by S75, S50 and S25 reaching 7.96, 7.21 and 6.74, respectively (P<0.05). The results obtained before freezing shows a highest level in SC0 whose animals were fed 100 % SBM in daily concentrate mix in comparison with all other groups (P>0.05).

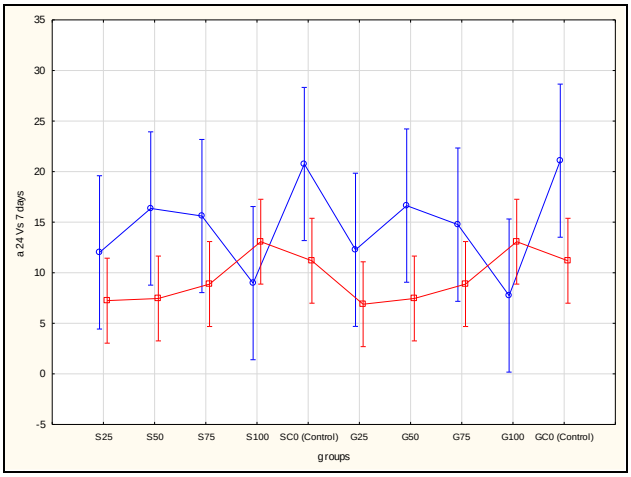

Fig.3. Comparison of redness (a) between Goat and sheep meat before and after freezing*

Meat quality as seen in figure 3 shows that better results for redness (a*) were achieved in animal groups GC0 (100 % SBM) before freezing at 24 h *postmortem* and SCO (100 % FBS) after 7 days of freezing in meat of goat and sheep as well, attaining 21.09, 20.75, 13.08 and 13.91, respectively (P>0.05).

It seems as proposed by Kerry *et al.* (2000) and Lawrie (1998) that the oxygenation of myoglobin, when meat is exposed to air, is responsible for the bright red color of lamb meat. The concentration of hemo-proteins such as hemoglobin, myoglobin and cytochrome C, their chemical states, the type of myoglobin present and the light scattering properties of meat are all factors influencing meat color.

Yellowness (b)

Figure 4 shows the results of Chromometer on yellowness of goat meat achieved before and after freezing. The color indicator b* was higher before freezing in G75 (19.07) animal group fed 25 % SBM: 75 % FBS in daily concentrate mix than all other groups G100 (17.77), G50 (15.15), GC0 (13.16) and G25 (12.44) whose animals were fed with daily rations 100 % FBS, 50% SBM: 50 % FBS,

100 % SBM and 75 % SBM: 25 % FBS, respectively (P>0.05).

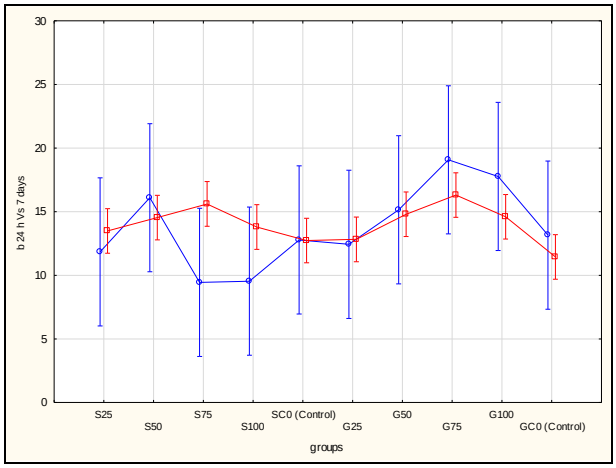

Fig.4. Comparison of yellowness (b) between goat and sheep meat before and after cooking*

Results of group G75 before and after freezing and S75 after 7 days of freezing reveal the fact that meat originating from animals fed 25 % SBM: 75 % FBS contains more fat than other groups fed different proportions of SBM: FBS. The highest level (P>0.05) of yellowness after 7 days of freezing was obtained in mutton of group S75 (15.61) whereas the lowest level was in group SC0 (12.73). This illustrates the fact that feeding 100 % SBM with rations as in group SC0 results in less fat in meat than other groups like in S75. Despite the fact that the level of yellowness (b*) indicating stored tissue fat was decreased as shown in S75 (P>0.05) after freezing, we notice that this indicator was pertained in group SC0 in after freezing (12.78) as it was at 24 h of cooling. It is worthy to mention that the lowest level (P>0.05) of yellowness before freezing in sheep meat was obtained in group S75 (9.44) and S100 (9.54) where animals were fed rations containing 75 % and 100 % FBS respectively.

In comparing the data obtained yellowness (b*) between goat and sheep meat before and after freezing shows that the highest level of b* was achieved in goat meat in group G75 before (19.08) and after (16.31) freezing (P>0.05) and GC0 (11) after freezing (P<0.05).

Even though yellowness before freezing was high in both species it was observed that this indicator decreases after freezing on much higher rates in mutton than goat meat (P>0.05).

Meat Tenderness

Juiciness is related to the water-holding capacity (WHC) and fat content of the meat. Dry meat is undesirable and excessive drip and exudation is a specific quality defect. Because, meat is sold by weight, drip loss must be minimized for economic reason. Meat from females is juicier than that of males, and meat from lambs slaughtered at medium weights is juicier than that of lambs slaughtered at lighter weights (Miller, 1994; Varnam and Sutherland, 1995; Vergara *et al.*, 1999).

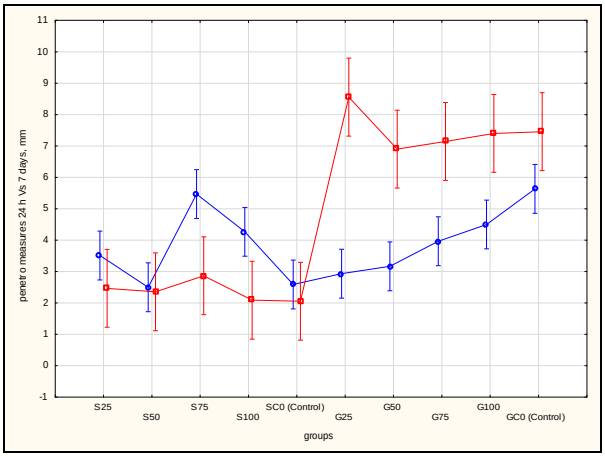

Fig.5. Comparison in penetration force between goat and sheep meat (mm)

Figure 5 shows that at 24 h *postmortem* meat after cooking attained lower level of tenderness (Penetrometer) than those obtained after 7 days of freezing. It was observed that in group G25 the penetration level of the needle after cooking attained the lowest level among the five goat groups (2.93 mm) and attaining the highest (8.56 mm) after thawing and cooking after 7 days of freezing (P<0.05). The lowest level (6.90 mm) of tenderness of goat meat was noticed in group G50 (P>0.05) after cooking after 7 days of freezing whose animals were fed rations containing equal proportions of SBM: FBS (50: 50) next to G75 (7.14 mm), G100 (7.40 mm) and GC0 (7.45 mm). Whereas this trait after 24 h for sheep the lowest was obtained in group SC0 (2.06 mm) in comparison with all other groups, S100, S50, S25 and S75 attaining the levels of 2.08, 2.36, 2.47 and 2.87 mm, respectively (P>0.05). It was noticed that as the amount of milled SBM increases in ration fed to sheep groups as in SC0 penetration level decreases attaining the lowest score after cooking in both refrigerating conditions, 24 h Vs 7 days (P>0.05).

Comparing the obtained results between goat and sheep meat as shown in Figure 5 we conclude that penetration force of cooked goat meat Vs cooked sheep meat before and after freezing was higher in all animal groups revealing more tenderness of goat meat.

Drip loss

Figure 6 shows the variations in the drip loss (DP, %) after 24 hours of refrigerating at 7° C between all animal groups of both sheep and goat meat. As it is observed from fig. 6

that the largest water loss was realized in both groups SC0 and GC0 fed daily rations containing no FBS, averaging to 22.69 and 24.27 %, respectively (P>0.05). The lowest losses was achieved in all groups containing different proportions of FBS: SBM as in S25, S50, S75, S100, G25, G50, G75 and G100 averaging to 9.15%, 12.80, 12.97, 13.05, 17.11, 13.57, 13.69 and 13.68, respectively (P>0.05).

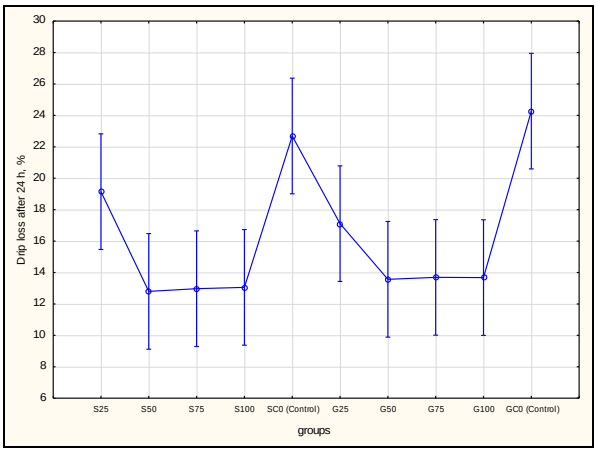

Fig.6. Variations in the drip loss (DL, %) after 24 hours of cooling between sheep and goat meat.

It is worthy to mention that SC0 and GC0 attained statistically significant (P<0.05) higher level of drip loss in meat water after 24 h of cooling in comparison with all animal groups except S25 and G25 where this decrease was insignificant (P>0.05).

Thawing Loss

Lawrie (1998) reported that water is generally held between the thin filaments of actin/tropomyosin and the thick myosin filament within muscles. He added that water can be either 'bound' or 'free' in muscles and a total of 75% of muscles are composed of water.

Figure 7 shows that as FBS proportion in rations fed to goat kids increases thawing loss increases, attaining the highest level 10.93 % in the 100 % SBM: 0 % FBS diet such as in group GC0. Despite the fact that neither G25 nor GC0 were significantly different with the results obtained in G25, G50, G75 and G100 (P>0.05) we observed that the difference between G25 (5.8 %) and SC0 (12.21%) was statistically significant (P<0.05).

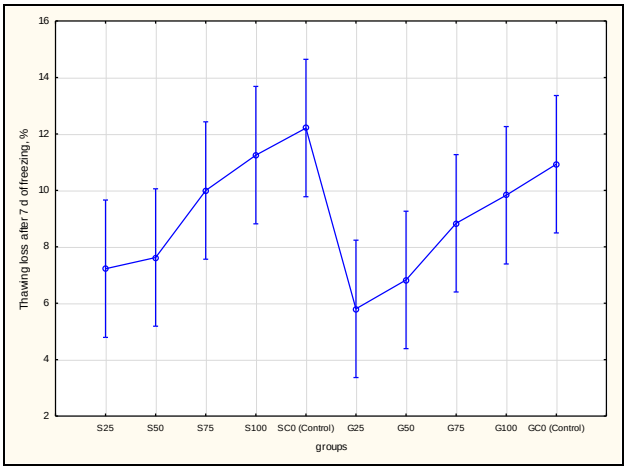

Fig.7. Variations in the thawing loss (TL, %) of meat after 7 days of freezing among sheep and goat meat.

The same tendency as in Goat meat was observed in thawing loss concerning mutton as shown in Figure 21, where the highest level of TL was attained in sheep group SC0 (12.21 %) fed with 100 % SBM and the lowest in group S25 (7.22 %) fed with 75 % SBM: 25 % FBS in rations (P>0.05). Thawing loss (%) in sheep was higher than that obtained in goat meat as shown in Figure 21 when comparing each two different animal groups fed with the same ingredients as in S25 and G25, S50 and G50, S75 and G75 and S100 and G100, SC0 and GC0 (P>0.05). The highest values (P>0.05) were in groups SC0 (12.21 %) and GC0 (10.93 %) and the lowest in S25 (7.22 %) and G25 (5.80 %).

Cooking Loss

Sales (1996**)** and Lawrie (1998) stated that the ability of meat to retain this water during the presence of external factors such as mincing, cutting and storage is known as the water holding capacity (WHC) of meat.

Figure 8 shows the different trends in cooking loss after 24h of cooling Vs after 7 days of freezing. It was noticed that water loss after cooking of those samples obtained after 24 h of cooling was highly significant (P<0.05) with those cooked after 7 days of freezing. On the graph we notice the same tendency in variations of high and low spots in both conditions. The least losses in water after cooking was registered in S50, S25, S100, S75 and SC0 losing weight after cooking averaging to 26.18% Vs 11.09%, 27.54 Vs 11.96, 28.25 Vs 12.28, 32.47 Vs 14.27 and 33.15 Vs 13.09% in both conditions, 24 h Vs 7 days, respectively (P<0.05). Although we observe a statistical significance (P<0.05) in some groups (G25, and G50) of cooking goat meat in both conservative conditions we notice a contradictory increase in groups G100 and GC0 where the loss increases P>0.05). As long as rations

fed to goats contain solely FBS% or SBM% as in groups G100 and GC0 we achieve higher losses in weight of goat meat after cooking after 24 h Vs 7 days, 18.88% Vs 21.38% and 29.47% Vs 27.13%, respectively (P>0.05).

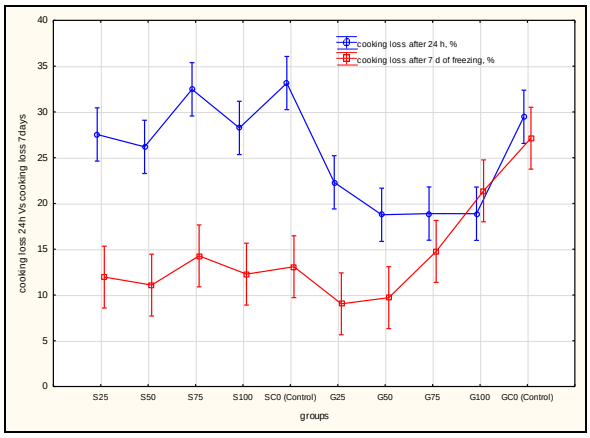

Fig.8. Variations in the sheep and goat meat cooking loss after 24 h of cooling and 7 days of freezing, %

There is a positive significant (P<0.05) correlation (r = 0.424) between color of meat before cooking and water holding capacity after cooking.

IV. DISCUSSION

However, during *postmortem* period, some meat quality parameters may be modified, e.g. pH, Water Holding Capacity (WHC), color and lipid oxidation (Tarsitano *et al*., 2013). The Meat freshness determines the choice of the product by the consumer (Xiong *et al*., 2015). Obtained results on meat pH24 (24 h *postmortem*) show average values between 6.6 for lamb meat and 6.7 for kid meat that can be evaluated as an acceptable quality level and therefore these values might be considered within the range of acceptable values (Hoffman *et al*., 2020). In a related context, Calnan *et al*. (2014) found in their obtained results that increasing pH24 across a range of 5.4 to 6 reduced meat redness (a*) in lamb meat. In contrast to what was achieved by the previous researchers, our findings showed a negative correlation (r=-0.4, P<0.05) between pH7 and a* (Appendix, Table 10) after 7days of freezing and not after 24 hours of cooling. In general, the freezing duration for 7 days in both lamb and kids meats as well showed significant increase (P<0.05) in meat pH where more acidic levels were illustrated after the period of 24 hours of cooling where pH results were basic. Note that, pH24 of goat meat was more basic than sheep and then decreased to become more acidic after 7 days of freezing than sheep with only exception in groups of sheep fed 25% and 75% FBS attaining more basic levels. Regardless of this fact, we notice more acidic levels in both control groups of sheep (SC0) and goat (GC0) longissimus muscle as well whose animals were fed 100% SBM. This is attributed to the presence of Soybean inclusion as the only protein legume source in ration. Time after maturation period of 7 days, pH values decreased. This result can explain about growth of lactic acid bacteria, which optimally grow at pH < 6.

In previous studies, the effect of FBS on meat pH was in conflict. Although some authors (Beriain *et al*., 2000; Ekiz *et al*., 2019) observed significant influence of FBS on meat pH24, some other studies found no significant variation among lambs slaughtered at different weight groups (Juárez *et al*., 2009). In the earlier studies, significant meat pH24 differences among different groups were generally attributed to differences in response to pre-slaughter processes (Ekiz *et al*., 2012a) or differences in glycolytic potential (Hopkins and Fogarty, 1998). In contrast, Oliveira *et al*. (1998), who tested the maturation of bovine biceps femoris muscle at 24 hours, 14 days, 21 days, and 28 days post-mortem, observed an increase in pH. The authors attributed this increase to the greater susceptibility of this muscle to enzymatic attack during maturation due to the increased osmotic pressure of the medium because of the breakdown of proteins into smaller molecules and the intramolecular reorganization of these proteins, which undergo changes in their electric charges.

Luminosity (L*), the red intensity (a*), and the yellow intensity (b*) displayed an increasing linear effect with maturation time of 7 days. With the increase in the maturation period, the meat becomes clearer with increase in a* and b* scores. With the increase in the maturation period, the meat became clearer, and there was also an increase in a* and b*. Live body weight of the animals in all stages of the trials was not seen as a correlated trait based on the findings of Tejeda *et al*. (2008) who found no effect of live weight on meat color. Besides that, Martínez-Cerezo *et al*. (2005) noted that a greater effect in meat color is brought about by a change in diet, than either carcass weight or age. It is worthy to mention that there is a significantly (P<0.05) negative correlation (r=-0.4) before freezing between a* and b* indicators after freezing. In other research the increase in L* may be related to the decrease in the final pH of these meats, as L* displayed an inverse correlation with the pH, indicating that the lower the pH, the greater the luminosity, i.e., the muscle appears clearer (Maganhini *et al*., 2007). Vasta *et al*. (2008) reviewed the quality of meat from sheep and goats offered alternative feeds legume seeds and pods as a replacement for concentrates. They found that many of these alternative feed resources (AFR) contain secondary compounds, such as tannins. Tannin-containing feeds result in meat of a lighter color and tend to increase protein

content, probably because they protect dietary proteins from ruminal degradation.

The red intensity (a*) is directly linked to the state and amount of myoglobin present in the meat. Low-pH conditions, such as those seen in meats with greater maturation times, cause a denaturation of globin, leaving the heme function unprotected, which leads to rapid oxidation of the metmyoglobin. According to Arima *et al.* (1997), the matured meat still displayed a different gradient when compared to the non-matured meat, even after equalizing the color, as the iron present in the myoglobin combined with the low oxygen tension turns into the oxidized form (Fe+++), leading to metmyoglobin, which displays a dark color.

The yellow intensity (b*) increased with the increase in the maturation period. According to Sañudo (2004), the increase in the maturation time of the meat tends to make it darker and browner; in other words, b* tends to increase over time.

Upon analyzing the refrigerated storage time of vacuum-packed pork, Apple *et al.* (2001) also obtained similar results for L*, a* and b*, reporting that the color of the loin becomes more vivid and that there is a greater red intensity when the refrigerated storage time is increased. Similar results were also found by Frederick *et al.* (2006), who tested vacuum-packed and refrigerated pork for 0, 4, and 8 days. As the maturation period increased, there was a linear increase in the mesophilic and psychrotrophic bacterial counts have led to the oxidation of the myoglobin into metmyoglobin, thus increasing a* (Taylor, 1985).

Low-pH conditions, such as those seen in meat with greater maturation times, because a denaturation of globin, leaving the heme function unprotected, which leads to rapid oxidation of the metmyoglobin. According to Arima *et al.* (1997), the matured meat still displayed a different gradient when compared to the non-matured meat, even after equalizing the color, as the iron present in the myoglobin combined with the low oxygen tension turns into the oxidized form (Fe+++), leading to metmyoglobin, which displays a dark color. No evidences of dietary effects on meat physical characteristics as a* and b* were found. Ultimate pH values were higher than those reported by Lanza *et al.* (2003a, 2003b) in lambs fed peas based- or chickpeas based diets (5.78 vs 5.5-5.6). The final pH values reflected that animals were not exposed to severe stress during pre-slaughter handling which is of major concern (Geesink *et al.*, 2001). Nevertheless SBM lambs in comparison with FBS showed average pH-value >5.8 which is considered undesirable (Devine *et al.*, 1993). The lack of significant differences in ultimate pH probably explained the absence of differences among groups in meat color. Lightness values were lower than those found in similar trials in meat from lambs fed different proportions either of peas or of fava beans (Lanza *et al.*, 1999, 2003b). Probably these differences could be attributed to the lower slaughter ages (around 100 days) compared to the age (139 days) in the trial of Lanza *et al.* (1999 and 2003b). Increasing the slaughter age is a well-recognized cause of lowering meat lightness (Santos-Silva *et al.*, 2002). The mesophilic microorganisms are important, as they are primarily acidifying microorganisms.

Meat color is an important criterion to judge the quality and freshness of meat at purchase by consumers (Ekiz *et al.* 2012a). Redness is closely associated with the state and amount of myoglobin in the meat. The luminosity (L*), the red intensity (a*), and the yellow intensity (b*) displayed an increasing linear effect with maturation time. Drehmer (2005) observed that the increase in the refrigerated storage of meat (0, 7, and 14 days) without using organic acids caused an increase in the mesophilic bacteria counts (2.72, 7.35, and 9.48 CFU/g with increasing refrigeration time). The bacterial load found in this study is within the standard established for meat fit for consumption. Mesophilic microorganism counts are used to indicate the sanitary quality of foods, yet mesophilic bacteria do not represent a potential risk to human health (Capta *et al.*, 1999).

The prolongation of ageing time up to one week of freezing, significantly affected some of the meat quality traits. Lightness, redness, and yellowness increased with prolonged ageing within SBM while in FBS, only redness was affected. This partially disagrees with Li *et al.* (2014), who only found an ageing time effect on lightness, but not on red- or yellowness in vacuum aged beef. On the other hand, color changes due to ageing have been previously reported for vacuum aged beef by Boakye and Mittal (1996). However, the meat color remained unaffected by ageing in SBM, which may be attributed to the high content of antioxidant carotenoids possibly transferred to the muscle tissue (Li and Liu, 2012; Soni *et al.*, 2017).

The drip loss percentage was obvious in animal groups (SC0 and GC) fed 100% SBM in the basic rations. More over thawing loss was higher after 7 days of freezing in sheep meat rather than in goats. Note that the highest losses were achieved in both control groups (SC0 and GC0) where animals were fed 100% SBM in the basic ration. It is worthy to mention that after strict observation it was found that as percentage of FBS in rations increase thawing loss increases linearly. Water loss represents a decreasing linear effect with maturation time; that is, the water retention capacity of the meat increased with the increase in the maturation time. During maturation, could not in fact be a slight increase in water retention capacity

due to the proteolytic action of cathepsins, which break down the enzymes of the myofibrillar structure, causing changes in the electrical charges of these proteins. Furthermore, Lawrie (2005) found that this breakdown in the ion-protein relationship increases the absorption of potassium ions (K+) and the release of calcium (Ca++) and sodium (Na+) ions. Roça (2000) added that this exchange of ions during maturation causes better water absorption. These results are in agreement with those found by Apple *et al*. (2001), who tested the effect of refrigerated storage on the quality of vacuum-packaged pork loins and identified a reduction in the water loss of the loin with increasing storage time (0, 4, and 8 weeks). The fluid lost in freezing present a decreasing linear relationship with maturation time. Due to the slight increase in the water retention capacity of the ageing meat, the fluid lost in freezing was also reduced. Although maturation may improve the water retention capacity of proteins, the post-mortem denaturation of the proteins and the decline in pH considerably contribute to a loss of muscle exudates (Lawrie, 2005). According to Miller *et al*. (1996) there is a greater loss of exudate during the refrigerated storage process, thus increasing the fluid lost during cooking. The fluid lost in cooking presented an increasing linear regression with maturation time. With increasing storage period, the water retention capacity of the muscle increases, and therefore, during cooking, there was a greater percentage of fluid to be released. This result was similar to that found by Apple *et al*. (2001), who reported that the percentage of liquid lost due to cooking increased linearly with increasing maturation.

The water holding capacity (WHC) of the meat can increase with time after finishing due to the proteolytic action of cathepsins, which break down enzymes of the myofibrillar structure and influence physioelectrical charges. These changes increase the absorption of ions such as potassium, calcium and sodium (Sung *et al*., 2017), while maturation time affects meat tenderness. Note that in our experiment maturation time of 7 days was tested where our objectives did not take into consideration more periods of maturation.

It is significant to mention that in our study penetration force in mm was used to test meat tenderness, which is a new way that could not be found in literature searches; instead, the traditional and most common method was in applying the shear force as Warner-Bratzler shear (WBS). Comparing the obtained results between goat and sheep meat we conclude that penetration force of cooked goat meat Vs cooked sheep meat before and after freezing was higher in all animal groups revealing more tenderness of goat meat. Tarsitano *et al*. (2013) reported that during the period after full maturation, shear force may decrease due to proteolysis of the myofibrillar structural components. When WHC decreases, shear force was observed to increase.

However, drip loss value of SC0 and GC0 (100% SBM) animal groups was significantly higher than all other groups in Awassi lambs and Baladi goat kids. In contrast with the current results, Vergara *et al.* (1999) found an increase in expressed juice value with increase in lambs fed FBS. In some previous studies (Ekiz *et al*., 2012b; Yaranoğlu and Özbeyaz, 2019), it has been reported that levels of expressed juice, drip loss and cooking loss are closely related with meat pH24. Ekiz *et al*. (2012b) found significant and negative correlation of pH24 with expressed juice and cooking loss. At higher muscle pH, proteins are able to bind with water more strongly and therefore less water is released (De la Fuente *et al*., 2010; Ekiz *et al*., 2019). However, in the current study, the correlation of pH24 with expressed juice, drip loss and cooking loss were not significant. On the other hand, Rajkumar *et al*. (2014) noted that increased meat water holding capacity in heavier lambs might be related to their higher fatness. One of the reasons of tougher meat in heavy lambs at slaghter might be the decrease in the amount of soluble collagen with increasing age and the increase in the number of heat-resistant linkages between the collagen fibres (Beriain *et al*., 2000). Supporting the current results, Ekiz *et al*. (2019) found no signicant differences among the meat of Kivircik lambs slaughtered at 25 kg, 30 kg and 35 kg weights regarding juiciness, odour and flavour intensity

Results of the study indicate that slaughter weight (SW) of young growing animals (at the termination of the experiment) has an evident influence on carcass and meat quality characteristics in both Awassi lambs (about 30 kg SW) and Baladi goat kids (about 20 kg SW).

Cooking loss values were lower than those reported by Lanza *et al*. (2003b) in meat from lambs fed different percentages of peas (19 and 39% on as fed basis) probably due to higher pH values.

Destefanis *et al*. (2008) attributed tough judgement to meat that showed penetrating force values less than 62.8N. Certainly, the different cooking method (waterbath) could have negatively influenced penetrating force values obtained in our experiment (from 2.5 to 5.5 mm).

The physical meat quality was not affected by the diets, including FBS or SBM partially or sololey. In contrast, Cutrignelli, *et al*. (2008a; 2008b) found a reduced water holding capacity in meat of faba-bean fed Marchigiana bulls. Calabrò *et al*. (2014) observed a slight

reduction in intramuscular fat content in meat of buffalo bulls fed fava beans instead of SBM. The authers added that he partial substitution of SBM by Fava bean seed fed to fattening lambs and goat kids did not affect meat color, which supports the present results obtained with a complete replacement of SBM by FBS. It also seems that including legume protein supplementation basic diets is without consequence for meat composition, water holding capacity, meat color, and meat tenderness of beef cattle (Geletu *et al*., 2021) which is comparable to the present study.

Prolonging ageing successfully promoted tenderization, as exhibited from the higher penetration levels and reported repeatedly by others (Lestingi *et al*., 2019). Note that all levels obtained in all goat groups after cooking after 7 of freezing days were significantly higher ($P<0.05$) meaning tender than those from sheep meat after 24 h of cooling in groups S25 (3.51 mm), S50 (2.50 mm), S75 (5.47 mm), S100 (4.27 mm) and SC0 (2.59). The penetration force presented decreasing linear behavior with maturation time; that is, it decreased as a function of the maturation time, making the meat tenderer. The shear force may have decreased due to proteolysis of the myofibril structural components, which occurs during refrigeration (Koohmaraie and Geesink, 2006). The values found indicate that maturation led to meats with a high degree of tenderness, and according to Boleman *et al*. (1997), shear force values for muscle less than 3.6 kgf/cm2 indicate extremely tender meat. Evaluating the effect of maturation (0, 8, 12, 24, 48, and 72 hours) on the texture of the meat from broiler chickens, Kriese *et al*. (2005) found that the sheer force increased with the maturation time.

Despite this fact, a stable minimal difference was observed in sheep meat after cooking, Koohmaraie *et al*. (1990) and Safari *et al*. (2001) concluded that the meat tenderness is the most important attribute affecting meat quality. Forrest *et al*. (1975), Tornberg *et al*. (1985) and Tshabalala *et al*. (2003) found that the ease of penetration, the ease with which meat breaks into fragments and the amount of residue that remains in the mouth after mastication, all contribute to the impression of meat tenderness. Lawrie (1998) reported that muscle fibers primarily affect tenderness where older animals have coarser muscle fibers and are thus tougher while younger animals have finer fibers. He also added that the connective tissue in young animals also has more soluble collagen linked to lower amounts of cross-bond connective tissue where, as animal age increases, the solubility of the collagen decreases, inducing a decrease in enzyme attack susceptibility. Meat becomes tendered *postmortem* through either a decrease in calpastatin and/or an increase in calpain activity that regulates protein breakdown (Therkildsen *et al*., 2002). However, Sazili *et al*. (2004) found that a feed restriction early in life, accompanied by an increase in growth rate before slaughter resulted in more tender meat than animals with a fast growth rate throughout their lives. Sazili *et al*. (2004) concluded that this effect is brought about by the interaction between protein synthesis and protein degradation on calpain and calpastatin activity.

V. CONCLUSION

The current study's research objectives broadly sought to evaluate the potential of Fava been seeds as alternative protein sources in feeds. The evaluation was designed around the *in vivo* evaluation the dietary effects of completely and partially substituting SBM with FBS on growth performance and meat quality. it was concluded that FBS qualified as potential legume protein sources in feeds and could be used /evaluated as feed ingredients with no risk of deleterious effects on growth (body mass, linear growth and physical meat quality) in growing male kids and lambs. Based on the present findings, SBM can be replaced by FBS legume protein sources on an isonitrogenous basis in diets comprising 50% SBM with 50% FBS concentrate without impairing performance, carcass and meat quality, thus confirming hypothesis. In summary, the 50: 50 and 75: 25 proportion of FBS: SBM improved the meat quality profile compared to values reported for conventional fattening diets, while maintaining reasonable animal performance and carcass and meat quality, without additional metabolizable protein-concentrate supplementation.

CONFLICT OF INTEREST

The auther certifies that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Study on the Physico-Chemical Properties of Cement Dust and the Possibility of Application in Agriculture

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Abstract— *Cement dust is created as a by-product during the production of cement, and in its composition it contains high concentrations of calcium oxide (CaO), potassium oxide (K_2O) and other important micro and macro elements. Due to its composition, it is suitable for correcting the pH of the soil, as well as for the uptake of essential elements by plants. The ability to accumulate essential and non-essential heavy metals also depends on the cultivated plant species, and vegetables show the greatest affinity for these elements. The application of cement dust as a soil additive used to improve the physico-chemical soil properties is examined in the paper. After the addition, the soil was mechanically cultivated and planting of the vegetable crop tomato was carried out. The content of essential elements and heavy metals was determined in the soil, cement dust, and tomato fruits grown on soil with and without the addition of cement dust. Due to the high pH value, high conductivity as well as the high content of CaO, it is very important to examine in real conditions how the addition of cement dust to the soil affects the formation of micro and macro elements as well as the content of heavy metals when growing tomatoes. The results showed that the cement kiln dust is an effective addition to the soil because it is a source of calcium, potassium and other essential elements without affecting the loss of quality or contamination with heavy metals during production.*

Keywords— ***Physico-chemical characterization, cement dust, heavy metals, tomato.***

I. INTRODUCTION

With the increase in the number of the population in the world, the need for food production has also increased, which conditions the investment of great efforts in the field of agricultural sciences with the aim of achieving maximum yields. Each plant for its growth and development has certain requirements in the supply of plant elements that plants mainly use from the soil [1] The fact that chemical substances are present in the environment does not necessarily mean their availability for adoption by living organisms or incorporation into them, i.e. their bioavailability [2]. Plants need macronutrients and micronutrients for their growth. The main difference is in the amount of each biogenic element that plants need. If it is about a larger amount that the plant requires during its life cycle, it is about macronutrients, that is, if the plant requires biogenic elements in small amounts, it is about micronutrients. However, there is no difference in importance; both are necessary for the proper growth and development of the plant [3]. Plants have a

highly specific mechanism of receiving and storing essential micronutrients from the environment, even at low ppm values. They also developed the mechanism of translocation and storage of micronutrients. These same mechanisms of receiving, translocation and storing also affect the absorption of toxic elements [4]. Heavy metals have multiple importance:

- they represent an important raw material for numerous industrial branches,
- some of them are essential for living organisms,
- they can have a favorable effect on agricultural productivity and
- most of them are often significant pollutants of the environment [5].

Heavy metals are characterized by different chemical, physical and physiological effects. Some of them are necessary for living organisms, such as: zinc (Zn), iron (Fe), molybdenum (Mo), manganese (Mn), cobalt (Co), selenium (Se), copper (Cu). Toxic metals are considered very dangerous pollutants and represent a great danger to all living organisms, humans, animals and plants [6]. Heavy metals are natural components of many food products, whether eaten fresh or processed [7]. The transfer of heavy metals from the soil to vegetables and fruits is the basis of the entry of heavy metals into the food chain [8]. The choice of the place of cultivation and the type of vegetables is very important because there can be too high a concentration (above MDK) in vegetables produced in gardens in urban areas. We can expect the lowest concentrations in fruit vegetables, and the highest in root vegetables [9]. It is considered that the toxicity of heavy metals is evident only if their concentration in pla[11],. nt tissue is increased above average values [10]. Disposal of cement dust is very difficult and causes danger to the environment. In order to minimize the adverse environmental impact of cement dust, many studies have been conducted to examine the beneficial commercial use of cement dust [11], [12]. Cement dust can be defined as a particulate material consisting of raw material, clinker particles and some calcined raw materials collected from the exhaust gas kilns of the Portland cement [13], [14], [15]. The use of cement dust in agriculture is useful and practical because it is a tool that improves soil properties and is a source of nutrients for plants. In many parts of the world, many researchers have proposed the use of cement dust to improve soil quality and increase yields [16]. X-ray diffraction analysis showed that the main components of cement dust are calcite ($CaCO_3$), quartz (SiO_2) and calcium sulfate ($CaSO_4$) [17].

The aim of the paper is to carry out the physico-chemical characterization of cement dust and examine the influence of its addition to the soil on the translocation of micro and macro elements as well as the content of heavy metals in tomato fruits in order to establish its positive agrochemical properties and the potential possibility of its use in agriculture.

II. METHODS

Material

The experimental study was conducted in the campus area of the University of Tuzla, on a land area of 500 m^2. A soil sample for analysis (about 2 kg) was taken from a depth of 0-30 cm, and after delivery to the laboratory, the pH value, conductivity, content of micro and macro elements and content of heavy metals were determined. After that, the physico-chemical characterization of the cement dust was carried out in order to determine the composition, pH value, content of micro and macro elements as well as the content of heavy metals. After the soil and cement dust analysis, cement dust was applied in the amount of 50 kg/100 m^2 per land surface, after which plowing was carried out. After 30 days, tomatoes were planted, where their growth and development were monitored in the period March-July, and after ripening, the fruits were delivered to the laboratory and analyzed.

Preparation of soil, cement dust and tomato fruits for analysis

Soil and cement dust samples were prepared by dry digestion [18]. The procedure consists in measuring a certain amount of the sample, which is then placed in a porcelain cup and burned by moderate heating for several hours, during which carbon, hydrogen, nitrogen and partially oxygen are converted into gases, while non-volatile oxides remain. The combustion process produces ash that is completely free of organic matter, which is a basic prerequisite for further analytical tests. The ash obtained by the combustion process is then dissolved in a mixture of acids, filtered and diluted to a certain volume, after which the solution is ready for analysis. Tomato fruit samples were prepared by wet crushing. The methods used for the analysis of heavy metals in food samples and environmental samples are based on different spectrometric analytical techniques: Atomic Absorption Spectrophotometry (AAS), Inductively Coupled Plasma Optical Emission Spectrophotometry (ICP-OES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) [19].

-For the determination of heavy metals, the method of emission spectrophotometry was used, using the Optical emission spectrometer “Perkin Elmer” ICP Optima 2100 DV.

-The content of alkali and alkaline earth metals was determined by flame photometry using Jenway/PFP7 Flame Photometer.
-Nitrogen content was determined by the Kjeldahl method, and phosphorus and potassium content by UV/VIS spectrophotometry using a flame spectrophotometer.
-Soil pH was determined using a pH ion meter. Determination of the pH reaction of the samples is carried out by weighing 10 grams of the sample transferred into a 100 ml beaker. The samples are then poured with 25 ml of distilled water, i.e. 1 M KCl, and mixed well with a glass rod. After 30 minutes, the pH value in the sample suspension is measured with a pH-meter which is properly calibrated with standard buffer solutions of known pH value [20].
-The chemical composition of cement dust was determined using the XRF method (X-ray fluorescence spectroscopy).

III. RESULTS AND DISCUSSION

Determining chemical properties of the soil, the content of macro and micro elements as well as the content of heavy metals in the soil is a basic indicator for determining the degree of pollution and the suitability of the soil for crop production.

Table 1. Significant physico-chemical properties of soil

Soil chemical properties	Content
pH(H_2O)	6.92
pH(KCl)	5.71
Electrical conductivity, EC (μS/cm)	34
Total N (%)	0.2685
Accessible K_2O (mg/100 g of soil)	8,0
Accessible P_2O_5 (mg/100 g of soil)	1,735

Determination of the pH reaction of the soil in water and KCl solution is carried out to determine the pH reaction of the soil, which is an indicator of a number of the soil agrochemical properties, important for plant nutrition, and is expressed in pH units. Based on the pH value of the soil, it can be concluded that the analyzed soil sample belongs to carbonate to slightly acidic soils, with a very low supply of nitrogen, phosphorus and potassium. Table 2 shows the chemical analysis of cement dust. From the obtained results, it is evident that cement dust has an extremely alkaline reaction and high conductivity, which is correlated with a high content of calcium and potassium oxides.

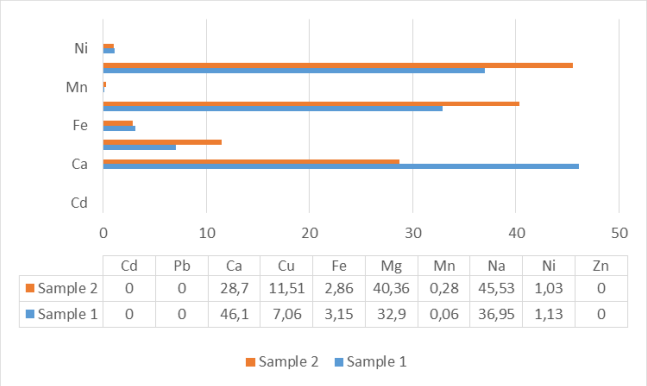
Table 2. Significant physico-chemical properties of cement dust

Cement dust chemical properties	Content
CaO (%)	65,40
Al_2O_3 (%)	3,55
K_2O (%)	8,68
Fe_2O_3 (%)	3,04
SiO_2 (%)	7,03
Cl (%)	4,54
SO_3	3,11
MgO	1,10
Na_2O	0,77
pH(H_2O)	12,76
pH(KCl)	12,70
Electrical conductivity (mS/cm)	5,31

Table 3. Content of essential and heavy metals in soil and cement dust (mg/kg, air-dried sample)

Sample	Soil	Cement dust
Cd	0.05	2.18
Pb	8.86	35.28
Ca	6456	18516
Cu	8.86	54.45
Fe	14133	6346.6
Mg	2761.6	2780
Mn	350	128.9
Na	332.8	1700
Ni	94.75	64.6
Zn	32.01	16.18

Based on the shown average values of essential and heavy metal content in Table 3, it can be concluded that the content of the tested elements in the soil and cement dust was within the maximum allowed values [21], except for the concentration of nickel in the soil, which was above the allowed values. The origin of nickel in the soil is explained as natural, given that the examined soil has not been cultivated for more than 10 years. Bioavailability and bioaccumulation of essential elements and heavy metals in plants is directly correlated with their content and mobility in the soil. Diagram 1 shows the values of the content of essential elements and heavy metals in tomato fruits in order to compare the obtained values with the regulations on the maximum allowed values [22].



	Cd	Pb	Ca	Cu	Fe	Mg	Mn	Na	Ni	Zn
Sample 2	0	0	28,7	11,51	2,86	40,36	0,28	45,53	1,03	0
Sample 1	0	0	46,1	7,06	3,15	32,9	0,06	36,95	1,13	0

Fig.1 Content of essential elements and heavy metals (data are expressed in mg/kg fresh weight)

Sample 1 – tomato fruits grown on soil with the addition of cement dust.

Sample 2 – tomato fruits grown on soil without the addition of cement dust.

Based on the average values of the analyzed elements (Ca, Fe, Mg, Mn, Na, Ni and Zn) in the tomato samples, the content was in accordance with the regulation on maximum allowed concentrations in vegetables (21). A higher uptake of calcium, iron and nickel was found in tomato fruits grown on soil with added cement dust, while the content of other elements was higher in pepper fruits grown on soil without cement dust. The determined values indicate a positive transfer of essential microelements from the soil to the vegetable fruit, although for a more accurate representation, the fraction of essential microelements accessible to the plant should also be analyzed. Namely, for plant nutrition, but also for food production and human health, the concentration available to plants is more important than the total amount. The content of highly toxic or non-essential metals (Pb, Cd) was not found in tomato fruits, which is very important from the point of view of safety. The content of Cu was above the value allowed by the regulations. A higher content of copper can be observed in samples of tomatoes grown on soil without added cement dust, which leads to the conclusion that the content of adopted copper is not limited only by its mobility from the soil, but also by other sources, of which copper-based vegetable protection agents are most often used. An excess of copper is thought to reduce the uptake and transfer of iron from the roots to the above-ground organs of plants, and suppresses other metals, especially iron, from physiologically significant centers. The use of calcium fertilizers or substrates that have a significant concentration of calcium in their composition (such as cement dust) aims to improve the quality of fruits in certain crops such as, for example, tomatoes [23].

IV. CONCLUSION

Cement dust is created as a by-product during the production of cement, it has a high pH value and is suitable for the soil pH correction.

Due to the high content of calcium, potassium as well as other micro and macro elements, it can be used as a soil additive at improving the fruit quality.

The content of the examined essential elements, as well as the content of heavy metals in the plant was within the permitted limits, except for the concentration of copper, whose concentration was above the permitted level. The assumed reason for the increase in copper concentration in tomato fruits is that a cooper-based vegetable protection agent is used.

In general, the results have shown that the cement kiln dust is an effective source of K and Ca for tomato production without short-term quality loss or soil metal contamination.

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Assessment of major dairy cattle feed resource availability and their chemical composition in Soro district of Hadiya zone, Southern Ethiopia

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Abstract— *In Ethiopia, the livestock industry is a vital and central part of the agricultural sector. Livestock farming is important for the supply of meat and milk; it also serves as a source of additional income both for smallholder farmers and livestock owners. This study was conducted to assess the available dairy cattle feed resources and analyze their chemical composition in Soro district, Hadiya zone of Southern Ethiopia. Single-visit-multiple-subjects formal survey technique was used to collect data with the use of pre-tested, structured questionnaires translated into the local language (Hadiyagna). From each of the nine kebeles, twenty households were randomly selected so that 180 households were involved in the study to collect the data. The data collected from individual farmers have been entered into Microsoft Excel (2010) spreadsheet. The major feed resources assessed in the study areas were natural pasture (76.7%), crop residues (63.3%), concentrate (37.8%), improved forages (30%), and others (enset waste, weed and browse trees). From the above feeds grass, wheat straw, teff straw, barley straw, wheat bran, Enset leaf, and Enset stem were collected for chemical analysis. The highest dry matter (95%) was recorded from grass and the lowest (89%) from wheat bran. The highest crude protein of (14.65%) was recorded from wheat bran and the lowest (6.05%) from teff straw. The higher fiber contents of 82.34% and 80.27% were recorded from wheat straw and teff straw, respectively. Hence, the major feed resources were natural pasture and crop residues that are of low quality with high fiber content, which may result in reduced livestock productivity and disease resistance. Therefore, feed shortage, water scarcity, disease, and low productivity of animals were assessed to be the major livestock production constraints.*

Keywords— ***Dairy cattle; Feed resources; Livestock; Chemical composition.***

I. INTRODUCTION

The livestock sector plays a significant role in the livelihood security of dairy farmers in the country. The rural economy mainly depends on agriculture and the allied sector, where animal husbandry and dairy development play an important role in supplementing the income of rural households, particularly, the landless, small, and marginal farmers (Thakkar et al. 2021). Ethiopia has a large livestock population and diverse agro-ecological zones suitable for livestock production and growing diverse types of food and fodder crops (Demissie, 2017). However, livestock production has mostly been subsistence-oriented and characterized by very low reproductive and productive performance. Ethiopia is believed to have the largest livestock population in Africa (Solomon et al. 2003; Helina and Schmidt, 2012). An estimate indicates that the country is home to about 54 million cattle, 25.5 million sheep, and 24.06 million goats

(Solomon, 2004). Of the total cattle population, 98.95% are local breeds and the remaining are hybrid and exotic breeds. 99.8% of the sheep and nearly all goat population of the country are local breeds (Samson and Frehiwot et al. 2014).

Currently, the livestock subsector supports and sustains livelihoods for 80% of the rural population. Despite the high livestock population and existing favorable environmental conditions, the current livestock output of the country is little (Samson and Frehiwot, 2014). This is associated with several complex and inter-related factors such as inadequate feed and nutrition, widespread diseases, the poor genetic potential of local breeds, market problems, marketing, and infrastructure (Friat and Haben, 2020). The large livestock population, the suitable climate for improved, high-yielding animal breeds, and the relatively disease-free environment for livestock make Ethiopia have a significant potential for dairy development (Abebe et al. 2008). Under the smallholder livestock production system, animals are dependent on a variety of feed resources which vary both in quantity and quality (Dawit et al. 2013). For optimum livestock productivity, the available feed resource should match the number of animals in a given area (Gashu et al. 2017). The availability of feed resources in Ethiopia depends on the mode and intensity of crop production as well as population pressure and interacts with rainfall amount and distribution

pattern, and season of the year (Mohamed-Saleem and Abate, 1995). Again, the availability of feed resources of the country has diversified based on agro-ecologies and farming systems, which vary from one locality to the other.

In Ethiopia, the human and animal populations are very much affected by nutritional problems, primarily due to a lack of food of high nutritional value (Gebrekidan et al. 2012). To solve this problem and to ameliorate the nutritional status of the population, measures should be taken to improve animal production to ensure a better supply of animal protein of high nutritive value. In this regard, milk is among livestock products whose demand continues to increase and plays a very important role in feeding the rural and urban population of Ethiopia. However, the quality and quantity of milk production deteriorate due to biological causes including poor nutrition, the low genetic potential of the animals, and the prevalence of diseases (Atyabi et al. 2006; Mesele et al. 2012). It is the most important factor in affecting either positively or negatively the potential of the animal. It is well established that poor nutrition and feed shortages are the root causes of the poor performance of livestock in Ethiopia (Tolera et al. 2007).

Livestock feed resources are classified as natural pasture, crop residue, improved pasture, and forage, agro-industrial by-products, and other by-products like food and vegetable refusal, of which the first two contribute the largest feed type (Alemayehu and Sisay, 2003; Bizelew et al. 2016 and Sefa, 2017). Animals depend mainly on natural pastures for their feed requirements. Natural pastures that provide more than 90% of the livestock feed are generally very poorly managed (Bikila and Tigist, 2016). In the mixed farming mid-altitude areas, better soils are used for cropping and the main permanent natural pasturelands are found on the upper slopes of hills and seasonally waterlogged areas (Tadesse and Solomon, 2014). Due to poor management and overstocking, natural pastures are highly overgrazed resulting in severe land degradation, loss of valuable species, and dominance by unpalatable species (Alemu, 1998).

Ethiopia is known for cereal crop production and the resulting crop residues could be used as a potential feed source for feeding dairy cattle to improve milk production. Though the country is estimated to have a huge supply of crop residues, there may be mishandling and a lack of awareness about crop-residue improvement (Adinew et al. 2020). Thus, the utilization efficiency of the residues is low. Besides, there may be a lack of proper selection of feeds for dairy cows for improving milk production, lack of market information about supplementary feeds, and also poor management of feeding systems which may lower the performance of cows. Hence, the producers may not get reasonable benefits from their dairy activity unless appropriate improvement strategies have to be introduced. Inadequate information about livestock feed resources and milk yield of both crossbreed and indigenous dairy cattle are the main problems in the Soro district. There is a problem with designing appropriate livestock feeding strategies to feed crossbreed and indigenous dairy cattle. Therefore, documenting the livestock feed resource and evaluating their chemical composition is crucial to designing appropriate interventions to enhance the productivity of both breeds of dairy cows in the area. Feed resource assessment in the area helps to design feeding alternatives during the worse season of the year to mitigate the dairy cows' feed shortage in the area. Therefore, this study aimed to assess the major available dairy cattle feed resources and evaluate their chemical composition in the Soro district of Hadiya Zone, Southern Regional State.

II. MATERIALS AND METHODS

The study was conducted at Soro district which was located in the Hadiya Zone of SNNP Regional State of Ethiopia. The district is approximately located between 10°17'-10°45'n latitude and 37°00'-37°10E' longitude. Hosanna and Gimbichu, the town of the district located in the south of Addis Ababa at a distance of 260 km, respectively. The mean annual T° of the Soro district is 17.27 C° and with elevations ranging from 501-2500 m.a.s.l. In the study areas, the annual rainfall pattern starts from June - September which receives 1001-1400 mm. The plain topography combined with the availability of optimum climatic and fertile soil conditions makes the district suitable for mixed crop-livestock production (HZARDO, 2013).

Study Design

A cross-sectional study design was employed to assess dairy animal feed resources. The cross-sectional study design was used and a cross-sectional visit of the study area was made for close observation of the overall livestock population and the available feed resource estimation. Focused Group Discussions (FGD) were held with elders, key informants, development agents, and district administrative officers working on the study areas to collect secondary data. Additional information on the potential Kebeles, livestock population and distribution, and locally available major livestock feed resources were obtained from the Soro Woreda Office of Agriculture and Rural Development and the locally developed organizational structure of the Kebeles (lowest administrative unit).

Sampling Technique: Soro district was selected purposively to collect the data about the available feed resources. There were three agro-ecological Zones in the Soro district (*Kolla*, *Dega*, and *Woynadega*). There were 20 Kebeles in "*Kolla",* 24 Kebeles in "*Woynadega*" and 5 Kebeles in "*Dega*". From these, 4 Kebeles from "*Kolla*", 4 Kebeles from "*Woyna Dega",* and 1 Kebele from "*Dega*" were purposively selected. From each of the 9 Kebeles, 20 households were randomly selected so that a total of 180 households were involved in the study to collect the primary data.

Representative samples of feed resources (pasture, crop residues, agro-industrial by-products, and locally available other feeds, etc.) which were commonly used in feeding domestic dairy cattle were collected from each selected Kebeles. In the beginning, the feed samples from grazing sites were taken from quadrats placed and demarked across diagonal line transects in the grazed area, and divided with systematically sampling procedures into 5 subsamples (top, bottom, middle, right and left positions) and 5 quadrats (0.5m x 0.5m) was harvested from each of the 5 subsamples. The grass in the quadrats was completely cut at ground level by sickle (manually). Finally, the samples of the same feed were mixed thoroughly and 1/3 of it was taken to Hawassa University, animal nutrition laboratory for further analysis.

III. METHODS OF DATA COLLECTION

Questionnaire survey: Single-visit-multiple-subjects formal survey technique was used to collect data with the use of pre-tested, structured questionnaires translated into the local language (Hadiyagna). The primary data collected included the general household characteristics of the respondents, landholding, and land use system, livestock herd size, and composition, the constraint of livestock, and the purpose of keeping livestock and livestock feed resources locally available feed resources (pasture and forage crops, crop residues, industrial by-products, and non-conventional feed resources) and feeding system. Secondary data was collected from the district and zonal offices targeting the feed resources available in the area, and the constraint of livestock.

A cross-sectional visit of the study area was made for close observation of the overall dairy cattle feed resource. Focused Group Discussions (FGD) were held by key informants, development agents, and district administrative officers working in the study areas to collect the data. Focus group discussions were held at each Kebele with 7 key informants selected from the study area, the researcher facilitated and guided the discussions, and the issues for discussion were livestock production system and utilization of grazing areas. Additional information was collected from the Soro district Office of Agriculture and Rural Development and the locally developed organizational structure of the Kebeles (lowest administrative unit).

Sample preparation and Chemical analysis: After completion of the survey, the dominant feeds were selected, air-dried, and taken to Hawassa University Animal Nutrition Laboratory and dried in an oven at 60^0C for 72 hours. Then all dried samples were ground separately to pass through a 1mm sieve of the Willey mill. The ground samples were kept in airtight plastic bags awaiting analysis. The determination of dry matter (DM), ash, and nitrogen (N) were done according to AOAC (1995). Crude protein (CP) was calculated as N * 6.25. Ash was determined by burning the sample at 550 to 600°C in a muffle furnace for 3 hours. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to VanSoest et al. (1991) using ANKOM ®200-fiber analyzer (ANKOM Technology Corp., Fairport, NY, USA).

Statistical analysis: The data collected from individual farmers have been entered in Statistical Package for Social Science (SPSS version 13). Leven's test was used to check the homogeneity of variances in the data analysis. Descriptive statistics (mean, standard deviation, frequency, percentages, table) were employed to summarize data on household characteristics; available feed resources, and feeding systems.

IV. RESULTS AND DISCUSSION

Analysis of dairy cows owner Household characteristics

Dairy cow owner household characteristics: The demographic information of respondents was presented in Table 1 below. The status of respondents in the selected Kebeles was 78.3% head, 16.1% wife, 3.3% son, and 1.1% daughter (Table 1). In Table 1 results revealed that the majority (80%) of the respondents were male. This result is in line with the *Azage* et al. (2003) finding report that most households were male-headed. The study further indicated that 41.7% of the respondents were illiterate. Moreover, the proportion of respondents who are capable of reading and writing only was 30% whereas 37.2% of the respondents attended formal education (1-8 grades). Regarding marital status, 96.1% of respondents were married and 3.9% were unmarried. The dominant farming system in the study area is a mixed crop-livestock type. Furthermore, farming was the major occupation in the district that was 79.4% and the rest 20.6% of the respondents were having additional jobs.

Table 1: Demographic information of respondents.

HH Status		Kolla	Weynadega	Dega	Total	%
Respondent status	Head	67	62	12	141	78.3
	Wife	5	17	7	29	16.1
	Son	4	2	1	7	3.8
	Daughter	1	1	1	3	1.6
Sex	Male	64	66	14	144	80
	Female	15	15	6	36	20
Educational level	Non formal	34	33	8	75	41.6
	Primary	32	22	9	63	35
	Secondary	8	12	1	21	11.6
	Adult literacy	5	10	2	17	9.4
Marital status	Married	76	79	18	173	96.1
	Unmarried	3	2	2	7	3.9
Major occupation	Farmer	72	53	18	143	79.4
	Trader	2	10	0	12	6.6
	Farmer & trader	5	16	2	23	12.7
	Retained	0	1	1	2	1.1

Landholdings and land-use systems in the study area: The land is among the most significant resources required for the effective application of any agricultural farming activities. The results indicated the average landholding per household for the four land-use types (annual crop, forest tree, grazing land, and perennial crop) in the district were 0.296±0.231, 0.141±0.024, 0.062±0.015, and 0.127±0.020, respectively, while the land used for Orchards and fallow was undefined (Table 2). Moreover, table 2 also showed that more land was used for annual crops and forest trees. Thus, the average landholding in the study area (0.63±0.058 ha) was lower than that reported for neighboring districts (0.69±0.02 ha) of Damot Gale (Fikre, 2009), and Dale districts (1.77ha) of the Sidama zone (Endashaw, 2007). This might be due to differences in the population density of the areas and differences in the farming system.

Table 2: Average land-use patterns and holding size (ha).

Land-use type	Highland	Midland	Lowland	Average
Annual crop	0.260±0.036	0.191±0.017	0.438±0.042	0.296±0.031
Forest trees	0.163±0.036	0.161±0.023	0.101±0.015	0.141±0.024
Grazing land	0.036 ±0.017	0.092±0.016	0.058 ±0.012	0.062±0.015
Orchards	_	_	_	_
Perennial crop	0.093±0.022	0.171±0.017	0.117±0.022	0.127±0.020
Fallow	_	_	_	_
Total landholding	0.55±0.01	0.62±0.073	0.714±0.091	0.63±0.058

Key. *Ha=hectare, SD=standard deviation*

Livestock herd size and composition: According to the survey results, most farmers kept more than one species of domestic animals. Results of this study indicated that in cattle livestock species, cows and oxen were the larger herd size and composition among the other types while bulls were the lowest classes in the entire three agro-ecological zones (Table 3). Additionally, in the case of sheep livestock species, ewes and lambs were the largest herd size in "*Kolla"* agro-ecological zone while Ewes were presented largely in *Woynadega* and *Dega* agro-ecological zones (Table 3). Furthermore, of the goat species, Does were the largest herd size than that of kids and bucks. Besides this, poultry was the largest herd size of all of the livestock populations in the study area. Generally, the present study showed that the possession of the farmers was higher for poultry than larger ruminants. This result agrees with the findings reported by Abdi et al. (2013); Estefanos et al. (2014); Bikila and Tigist, (2016). The sheep, goats, and poultry were the means of risk aversion in case of natural disaster or any incidence of disease outbreak, some farmers preferred to keep sheep and goats because they were easy to manage and accommodate in a smaller area than large ruminants.

Table 3: Livestock herd size and composition in the study areas.

Species	Types	Kolla Mean±SE	Weynadega Mean±SE	Dega Mean±SE	Total mean±SE	P<0.05
Cattle	Cow	2.73±0.22	2.69±0.16	2.30±0.25	2.57±0.21	0.57
	Oxen	2.24±0.12	1.54±0.10	2.00±0.12	1.92±0.11	0.00
	Bull	0.21±0.05	0.24±0.05	0.45±0.11	0.30±0.07	0.12
	Heifer	1.16±0.14	0.41±0.08	0.45±0.18	0.67±0.13	0.00
	Steers	1.04±0.16	0.54±0.09	0.45±0.13	0.67±0.12	0.01
	Calves	1.45±0.10	1.44±0.08	1.37±0.14	1.42±0.11	0.91
Sheep	Lamb	0.57±0.15	0.73±0.09	1.65±0.15	0.98±0.13	0.00
	Ewes	0.67±0.10	1.11±0.13	1.55±0.19	1.11±0.14	0.00
	Ram	0.29±0.08	0.54±0.07	1.15±0.13	0.66±0.09	0.00
Goat	Does	0.95±0.15	0.78±0.11	0.65±0.18	0.79±0.14	0.49
	Kids	0.69±0.12	0.48±0.07	0.40±0.11	0.52±0.10	0.18
	Bucks	0.29±0.06	0.38±0.06	0.30±0.10	0.32±0.07	0.55
Equine	Donkey	0.88±0.08	0.89±0.08	0.30±0.10	0.69±0.08	0.00
	Mule	0.21±0.04	0.33±0.05	0.15±0.08	0.23±0.05	0.11
	Horse	0.05±0.04	0.07±0.04	0.10±0.07	0.07±0.05	0.84
Poultry	Poultry	7.05±0.39	6.39±0.25	5.60±0.57	6.34±0.40	0.09

Key: SE=Standard error.

Constraints of livestock production: The results indicate that feed shortage is the major constraint identified by most of the respondents. The results of this study showed feed shortage (62.8%) followed by disease (25.5%), low productivity (10%), and water shortage (1.1%) in all three agro-ecological zones (Table 4). The primary constraint of dairy cattle production in the study area was feed shortages followed by a frequent outbreak of major livestock diseases. Feed shortage in the study area might be associated with cropland expansion that results in a shortage of grazing lands. The observations are in agreement with that of Dawit et al. (2013) farmers indicated that increment in cropland at the expense of grazing land, shortage of land for forage production, renting, and allocation of open grazing lands around Lake Zeway for investors have resulted in a decrease grazing land. Moreover, in the three agro-ecological zones the major feed shortage was observed in Dega agro-ecological zone, which was about 70% and next was recorded in *Kolla* (66.25%) while the lowest (57.5 %) was in Woynadega (Table 4). The result is in agreement with that of Keftasa (1996) and Dawit et al. (2013) they also indicated that the shifting of grazing land into crop cultivation has dwindled the potential of the livestock in the area and put immense pressure on the existing land. Furthermore, the results indicated that the most prevalent diseases reported in the three study areas included were: blackleg, foot and mouth disease (FMD), anthrax, and fascioliasis. The interaction of these constraints affects the overall production in the study area. These results are similar to Mulu, 2009; Duguma et al. 2012 and Kaassahun et al. 2015; Ashenafi and Melaku, (2020) reported that the major constraints of livestock production are feed shortage and animals health problems are closely linked to the kind of environment in which the herd is kept and the management methods used in the production system.

Table 4: Constraints of dairy cattle production as identified by respondents.

Constraints	Kolla	Weynadega	Dega	Percentage
Feed shortage	53	46	14	62.8
Disease	22	21	3	25.5
Low productivity	3	13	2	10
Water scarcity	1	1	0	1.1
Others	0	0	0	0

Purposes of keeping livestock: According to the respondents, farmers kept cattle for many purposes in the study area. The major purposes were milk (41 %), draft power (22.2%) meat (11.1 %), saving (8.3%), income generation (5.5%) and manure (5.5%) (Table 5). These results agreed with the results reported by Abera (2012) the majority of the respondent keeps cattle mainly for milk, meat, and saving which is comparable with current the study, and farmers use cattle manure as a source of fertilizer. However, no one kept the cattle for hide and skin. For these purposes, major attention was given to draft power because most of the farmers have at least one pair of oxen to plough the land. However, the main reasons for raising small ruminants were meat production, saving, income generation, and manure production with higher priority given to income generation which was about (61.1%) followed by meat production (28.9%) while the others were 1.66 %, 6.11 % and 2.22 % for saving, hide and skin and manure production respectively. Among the different reasons outlined in table-5, the farmers used equine and cattle (oxen) for draft power. Cows were the only source of milk production whereas milk from small ruminants was not consumed in the area because of cultural taboo.

Table 5: Purpose of keeping livestock in the study district.

Livestock	Purpose of livestock keeping						
	Meat	Milk	Draft power	Income	Saving	Hide & Skin	Manure
Cattle	20(11.1)	75(41)	40(22.2)	10(5.5)	15(8.3)	_	10(5.5)
Small ruminant	52(28.9)	_	_	110(61.1)	3(1.7)	11(6.1)	4(2.2)
Equine	_	_	167(92.8)	_	_	_	13(7.2)

Major feed resources for dairy cattle: According to the result of respondents, grazing natural pasture and crop residues was ranked as the first and second most important feed resource in the study area. In Table 6 results revealed that the respondents ranked enset as the third most important feed resource in the study area mostly in highland and midland areas. Moreover, improved forage and industrial by-products were obtained from the by-product of wheat milling which is wheat bran widely used in urban areas and ranked fourth and fifth. The result of this study was in agreement with that of Miresa and Demeke (2020) and Gebretsadik, (2019). Results in Table 6 revealed that the major available feed resources in the study area were natural pasture, enset, crop residues, hay, an industrial by-product, and forage crop aftermath. The results indicated that the major feed resources were natural pasture (76.6%), crop residues (63.3%), Wheat straw (17.8%), teff straw (51.1%), barley straw (11.7%), sorghums (4.4%), maize Stover (15%) and concentrate (37.8%), wheat bran and noug seed cake, improved forages (30%) and others (enset waste, weed and browse trees) (Table 6). However, crop residues, natural pasture, and aftermath grazing were the major feed resources for the dry season. Crop residues from cereals such as wheat, teff, and barely were common in the study area. Teff straw, maize stover, and sorghum stover were available in large mass in the low land area which was *"Kolla"* agro-ecological zone, whereas wheat straw, barley straw, teff straw, grass, and enset were largely presented in midland areas (*Woyna dega*) while wheat straw, barley straw, and grass were common in high land area (*Dega*).

In the study area most of the time the farmers were used enset in the dry and wet seasons. Enset was a widely cultivated crop in mid (sub-humid) and highland districts of the area, which was used for both human and livestock food. An enset part (leaf and pseudostem) was usually fed to livestock during the dry season. Enset root was fed for fattening oxen and sheep, and to heal sick animals. The importance of enset for livestock feed has been reported previously Adugna, (1990); Amsalu et al. (2008), and Deribe et al. (2013). In the highlands, the natural pasture, crop residues (wheat straw and barley straw), and weed were the major sources of feed. This statement agreed with reports presented by Alemayehu and Sisay, (2003); Bilatu et al. (2018).

Table 6: The major available feed resources as ranked by farmers.

Feed resource	Ranked (Number of responses)					
	Rank1	Rank2	Rank3	Rank4	Rank5	(Rank) mean index
Natural pasture	60	66	30	31	33	0.277(1)
Crop residue	54	42	29	18	23	0.216(2)
Industrial by-product	30	7	50	20	30	0.147(5)
Improved pasture	12	50	35	35	42	0.176(4)
Enset	24	15	36	76	52	0.182(3)
Total	180	180	180	180	180	1.00

Index = [(5 × number of responses for 1^{st} rank + 4 × number of responses for 2^{nd} rank + 3 × number of responses for 3^{rd} rank + 2 × number of responses for 4^{th} rank +1 × number of responses for 5^{th} rank)] divided by (5 × total responses for 1^{st} rank + 4 × total responses for 2^{nd} rank + 3 × total responses for 3^{rd} rank + 2× total responses for 4^{th} rank + 5×total responses for 5^{th} rank).

Feed resources during dry and wet seasons: As presented in Table 7, during the dry season, (85.6%) of the respondents have used crop residues as the number one feed resource followed by hay (82.2 %) and industrial by-product (65%). The results revealed that the majority of the respondents indicated that crop residues from wheat straw, teff straw, maize stover, barley straw, bean, and peas residues were important feed sources, especially during the dry season when the availability of pasture was low (Table 7). The present study was in agreement with the reports of Berihu et al. (2014). According to the data obtained from the respondents in the study area, in the wet season, the respondents used natural pasture (88.9%), fodder trees (75%), and improved forages (71.7%) (Table 7). This result is similar to Tesfaye's (2007) reported that the wet season feed resources were natural pasture followed by fodder trees and improved forages.

Table 7: Dry and wet season feeds in the study district.

Feed type	Dry season		Wet season	
	Frequency	Percentage	Frequency	Percentage
Natural pasture	45	25	160	88.9
Crop residues	154	85.6	32	17.8
Hay	148	82.2	26	14.4
Fodder tree	20	11.1	135	75
Industrial by-product	117	65	63	35
Improved forages	51	28.3	129	71.7

Feeding system: Livestock owners were followed different feeding systems for efficient utilization of the available feeds. In the study district 67.8%, 18.9%, and 13.3% of the respondents were fed their animals with feeding systems of grazing and stall-feeding, only grazing and only stall-feeding respectively (Table 8). In Table 8 results revealed that the more practiced feeding system was grazing and stalls feeding systems. More farmers only used grazing to feed their cattle in lowland areas. This was due to the availability of grazing land in lowland areas which was better than the midland areas while cut and carrying (only stall-feeding) feeding systems were more in the midland and highland area. Furthermore, the responses given by the respondents during the survey time, in lowland areas, many farmers have practiced a group feeding system and in that feeding system, all age categories of animals were fed together so that it was difficult for younger animals to satisfy their daily dry matter requirement as some of the animals can consume more than others and fight each other. Most of the time in high land areas farmers practiced let to graze, cut and carry, and tethering.

Table 8: Percentage and frequency of feed resources and feeding systems.

Feeding system	Frequency	Percentages
Grazing & stall feeding	122	67.8
Only grazing	34	18.9
Only stall feeding	24	13.3

Communal and Private grazing land availability: In the study area, the farmer used both communal and private grazing lands. Farmers in kebeles mostly use private grazing land because the communal grazing land was changed to crop cultivation and decreased from time to time and this indicated that the quantity of livestock feed obtained from this source was also decreased. Results indicated that respondents responded that allocation of communal grazing lands for landless youths and expansion of croplands were the major reasons for decreasing the size of communal grazing land in their respective areas. This result is similar to Wocat, (2012) reported that communal grazing areas were increasingly being converted into cropland due to rapid population growth.

Chemical composition of major feeds in the study area: The chemical composition of the top seven major feedstuffs in the study area were shown in (Table 9) below. The content of dry matter (DM) was relatively high (95%) in grass feedstuff compared with the others while the lowest value of DM was recorded in wheat bran. In general, the DM compositions for all feedstuffs analyzed in this study were relatively high. According to the result obtained in this study, the crude protein (CP) of the wheat bran and enset leaf was high. Moreover, the crude protein (CP) of the wheat straw, teff straw, barley straw, grass, and enset stem were comparable. The crude protein (CP) content (6.48 %) of the grass recorded in this study was slightly lower than the value (9.6%) reported by Solomon (2004). Furthermore, the results of this study indicated that the CP content of wheat bran, wheat straw, teff straw, barley straw, grass, enset leaf, and enset stem was: 14.65, 6.65, 6.05, 6.06, 6.48, 13.75, and 6.74, respectively (Table 9). Similarly, Lonsdale (1989) reported the crude protein CP (14.65%) content of wheat bran. However, compared to the study, the reports of Asnakew and Simret, (2005); Fentie and Solomon, (2007) on the CP content of wheat bran were (19.55, 20.10, and 23.08 %) respectively higher. Similar to this finding Solomon et al. (2021) reported. The differences between the results might be due to the

variation in the raw material, methods of chopping or milling, and the extended storage of the samples.

The results of the current study indicated that the NDF content of all crop residues was above 40%. Similarly, Singh and Oosting, (1992) reported that roughage feeds with NDF content of less than 45% are categorized as high quality, 45 to 65% as medium quality, and those with more than 65% as low-quality roughages. In this study, the contents of NDF were more than 65%, so all crop residues might be categorized as low-quality roughages that may reduce animal performance. Table 9 result also revealed that the contents of NDF for the feedstuffs of Enset leaf, Enset stem, and grass were 57.27, 61.97, and 64.64 respectively. So, these results might be considered medium-quality feeds according to the statements of (Singh and Oosting, 1992; Usman et al. 2018). Whereas, wheat bran was categorized under high-quality feed which was below 45 %. The NDF value of wheat bran in the present study was lower than earlier reported values (55.50, 44, 44.13, 44.97, 43.83, 44.94, and 39.16%) by Hirut (2008), Simret (2005), Mulat (2006), Fentie and Solomon, (2007), Abebe and Jemberu (2008), respectively.

Likewise, the ADF content of wheat bran in this study was lower than in earlier reports (12.70, 12.47, 12.36% 12.39, and 12.45%) by Solomon et al. (2004), Simret (2005), Asnakew (2005), Fentie and Solomon, (2007), and Jemberu, (2008), respectively. However, the ADF content was higher than those reported by Giri et al. (2000) and Tesfay (2007) (9.49% and 9.46%, respectively). According to the results of the present study, the lignin content of grass, wheat bran, and enset steam were comparable. Based on the lignin content, the different crop residues could be categorized as low-quality roughages. Furthermore, the results indicated that the lignin content was high for all crop residues except teff straw, which is beyond the maximum level of lignin (7%), which limits DM intake. The ADL of grass was lower than 7%, which was medium quality roughages, and feed staff. The ether extract (EE) contents of these feeds (grass, wheat straw, teff straw, barley straw, wheat bran, enset leaf, and enset stem) were 2.22, 0.38, 1.33, 2.70, 3.18, 6.56, and 1.34, respectively (Table 9).

Table 9: Chemical composition of major feeds in the study area.

Feeds	**Chemical composition**							
	% of Nutrient composition (in DM base)							
	DM	OM	AS H	EE	CP	NDF	ADF	ADL
Wheat straw	93.2	91.48	8.52	0.38	6.65	82.34	47.76	7.26
Teff straw	93	92.79	7.21	1.33	6.05	80.27	40.59	4.85
Enset leaf	94.5	68.48	31.52	6.56	13.75	57.27	22.44	4.72
Barley straw	94.7	88.82	11.18	2.70	6.06	79.97	48.97	7.62
Grass	95	85.47	14.53	2.22	6.48	64.64	32.61	3.80
Wheat bran (supplement)	89.4	95.55	4.45	3.18	14.65	40.82	10.85	3.27
Enset stem	94.6	88.49	11.51	1.34	6.74	61.97	41.82	3.61

Key: *ADF=acid detergent fiber; ADL=acid detergent lignin CF=crude fiber, CP= crude protein, EE=ether extract, DM= dry matter, NDF=neutral detergent fiber.*

V. CONCLUSION

According to the survey, the major available feed resources for dairy cattle in the study area were natural pasture, crop residues, concentrate, improved forages, and others (enset waste, weed and browse trees). Crop residues, natural pasture, and aftermath grazing were the major feed resources for the dry season and with high fiber content and low digestibility, which could decrease livestock productivity and disease resistance. The reason for the feed shortage in the study area is an expansion of cropland. Therefore, the size of grazing land decreases from time to time which leads to a shortage of feed resources in the study area. To increase livestock productivity, the primary focus needs to be on improving the existing feed resources through management, utilization practices, and applying improvement practices such as treatment of crop residues, and improving the existing management system of grazing land. Thus, training and extension advice is urgently required in handling crop residues, feeding, healthcare, and market information to improve the performance of dairy cattle in the study areas. Finally, awareness should be given to farmers on how to conserve forage and hay to overcome feed shortages during the dry season.

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AUTHOR'S CONTRIBUTION

DB: Conceived and designed the study; Data collected and analyzed and wrote the paper. TW: Received the draft; make scientific comments and revised it; wrote the paper and discussed the interpretation. And he handled the whole process from journal selection up to publication. Additionally, he covered the manuscript payment cost.

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Evaluation of the Phytochemical and Antibacterial Activity of Four Selected Plant Extracts against Some Pathogenic Bacteria

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Abstract— *This study aimed to evaluate the phytochemical and antibacterial activity of Acanthus eminens, Celosia trigyna, Drymaria cordata, and Phytolacca dodecandra against the selected pathogenic bacteria; Two strains of Gram-positive (Staphylococcus aureus and Bacillus cereus) and three strains of Gram-negative (Escherichia coli, Salmonella typhi, and Pseudomonas aeruginosa) bacteria. The presences of phytochemicals were analyzed using the standard methods of phytochemical analysis, while the antibacterial activities were analyzed using the disc diffusion method. The results indicated the presence of terpenoids, cardiac glycosides, saponins, flavonoids, and alkaloids in the extracts of A. eminens and C. trigyna. Alkaloids, flavonoids, and phenols are present in the extract of D. cordata and P. dodecandra. Methanolic extracts of Acanthus eminens, Celosia trigyna, Drymaria cordata, and Phytolacca dodecandra were potentially effective with variable efficiency against the tested bacterial strains at a concentration of 4 mg/ml while Celosia trigyna extract was found to be the most effective with a concentration of against all tested bacterial strains. On the other hand, Phytolacca dodecandra extract was found to be effective with a concentration of against B. cereus, S. aureus, S. typhi, and P. Aeruginosa suppressing their growth with inhibition zones of 10.3, 16.7, 11.6, and 11.1 mm, respectively. Celosia trigyna and Phytolacca dodecandra methanolic extracts were the most effective plant extracts and showed bacteriostatic and bactericidal activities against the highly susceptible strains of pathogenic bacteria (Bacillus cereus, Staphylococcus aureus, and Pseudomonas aeruginosa) with MIC's ranging from 20 to 0.8 mg/ml and MBC of 4.0 and 0.16 mg/ml, respectively. These plant extracts have high potential antibacterial effects on bacterial strains tested, especially Bacillus cereus, Staphylococcus aureus, and Pseudomonas aeruginosa. They have been highly effective to be used as a natural alternative treatment to control pathogenic bacteria.*

Keywords— ***A. eminens, C. trigyna, D. cordata, P. dodecandra, phytochemicals, antibacterial activity, HPLC-UV.***

I. INTRODUCTION

In the modern world, multiple drug resistance has developed against many microbial infections due to the indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of infectious diseases. In addition to this problem, antibiotics are sometimes associated with adverse effects on the host including hypersensitivity, immunosuppression, and allergic reactions. Therefore, there is a need to develop alternative antimicrobial drugs for the treatment of infectious diseases from medicinal plants. Plants are one of the most important sources of medicines for treating illnesses since the beginning of human civilization [1-3]. Plants in general

and high-valued medicinal plants specifically, have a long history of use as a source of cheap and effective remedy for various ailments [4]. The use of plants and herb extract in the treatment of human ailments is a very ancient art, a practice that has been passed on for generations and Scientists in Africa and other developing countries are researching local plants abundant in the continent for their possible use in traditional medicine. Plants are the richest repository of drugs for traditional medicines, modern medicines, folk medicines, pharmaceutical intermediates, and chemical entities [5-7]. It is important to mention that traditional medicinal systems are at a transitional stage in the development of modern medicines in developing countries. Therefore, the use of neglected and little-known medicinal and aromatic plants must be promoted and encouraged at regional as well as global levels for the betterment of mankind [8].

The study on medicinal plants is essential to promote the proper use of herbal medicine to determine their potential as a source for the new drugs [9]. Antimicrobials of plant origin have enormous therapeutic potential. They are effective in the treatment of infectious diseases while simultaneously mitigating many of the side effects that are often associated with synthetic antimicrobials [10]. Drug-resistant bacteria and fungal pathogens have further complicated the treatment of infectious diseases. In recent years, drug resistance to human pathogenic bacteria has been commonly reported from all over the world. However, the situation is alarming in developing as well as developed countries due to the indiscriminate use of antibiotics [11].

Some researchers reported that ethanolic clove extract was potentially active against *S. aureus, Vibrio parahaemolyticus*, and *P. aeruginosa* while it was inactive against *E. coli* and *Salmonella enteritidis* [12]. Other researchers ascertained the activity of clove oil against all tested pathogenic bacteria while *Vibrio cholera, S. typhi*, and *Klebsiella* pneumonia were found to be resistant to aqueous clove extract [13, 14]. Moreover, the methanolic clove extract was reported to be potentially effective against *S. aureus*, *P. aeruginosa*, and *E. coli* with MIC ranging from 0.1 to 2.31 mg/ml [15]. The evaluation of plants for their potential application based on their medicinal properties is important for modern-day medicine as the widespread and long-term use of antibiotics has led to the emergence of multi-drug-resistant strains, besides several side effects. The adverse effects of these synthetic drugs can be overcome by using traditional or herbal formulations which are safe, efficacious, and multifunctional. Further, the development of herbal medicines based on ethnomedical leads is relatively easier in comparison to synthetic drugs [16-18]. In the present scenario of the emergence of multiple drug resistance to human pathogenic organisms, this has necessitated a search for new antimicrobial substances from natural sources including plants. Plant and plant products play a wide range of antimicrobial properties.

II. MATERIALS AND METHODS

2.1. Plant materials Collection and Authentication. The raw material of medicinal plants *Acanthus eminens* (stems), *Celosia trigyna* (leaves), *Drymaria cordata* (leaves), *Phytolacca dodecandra* (roots) was collected from the medicinal plant's farm of Bonga University. The plant materials were washed, disinfected, rinsed with distilled water, and spread out and dried in the chemistry laboratory at room temperature for about thirty days. Dried samples of plants materials were milled into a fine powder using a high capacity grinding machine and subsequently stored separately in sterilized polythene bags in the refrigerator at the temperature of 4ºC until required for use. The plants are deposited and voulcher numbers were given by at the National Herbarium of Addis Ababa, Ethiopia. The four selected medicinal plants were authenticated by Botanist Mr. Seyoum Robo at Bonga University.

2.2. Extracts preparation. 100 g of the fine powder of plant materials were soaked in 300 ml of methanol with stirring for 72 hours, filtered through double layers of muslin, centrifuged at 9000 rpm for 10 min, and finally filtered again filtered through Whatman No1 filter paper and concentrated using a rotary evaporator at 40˚C. The resulting crude extracts were weighed and stored in the refrigerator until phytochemical screening and antimicrobial activity were carried out. The extract yields were weighted, stored in small bottles in Fridge at 5°C and their yield percentages were calculated using the following formula: Extract yield % = Q/T x 100 (where Q; the weight of extracted plants residues and T; the weight of plant powder).

2.3. Antibacterial activities of the selected plant extracts: Bacterial strains. The antibacterial potency of each plant extract was evaluated using five bacterial strains. Bacterial strains: *Staphylococcus aureus* and *Bacillus cereus* were Gram-positive and *Escherichia coli*, *Salmonella typhi*, and *Pseudomonas aeruginosa* were Gram-negative bacteria. The bacterial strains were provided from the culture collection of the Mizan-Aman research center.

Table 1: The ethnobotanical data of selected medicinal plant species and their extract percentage yield.

Plant species	Family	Local name	Common name	Plant part used	Extract yield (%)
A. eminens	Acanthaceae	Phecho	Acanthus	Stems	4.63
C. trigyna	Amaranthaceae	Degicho	Woolflower	Leaves	3.27
D. cordata	Caryophyllaceae	Hakeato	Drymaria	Leaves	6.54
P. dodecandra	Phytolaccaceae	Yengamo	Endod	Roots	8.74

Table 1.1: Medicinal plants with mode of preparation used by local people from Kafa Zone, Southwest, Ethiopia. Habit: Tree (T), Herb (H), Shrub (S), Climber (C).

Synthetic Name	*Voucher name*	Habit	Parts Used	Disease and Mode of application
Acanthus eminens	*16191*	S	Stems + Leaves	Infusions of leaves of used for backache, skin diseases, cough, eye infections, wounds, pneumonia, anti-diarrhea and edema.
Celosia trigyna	*MG-S67-2005*	H	All parts	The whole parts are chopped and the sap is used for Arthritis, Diarrhea, Dysentery
Drymaria cordata	*MG-S30-2005*	H/C	Leaves	The sap is used for treating respiratory chest-ailments, colds and bronchitis.
			Above ground Part	The aboveground parts of the plant are fumigated to heal and alleviate the severe headache or migraine.
Phytolacca dodecandra	*MG-S4-2004*	S	Leaves	Infusion from leaves is used to control external parasites in livestock in general by washing their whole bodies.
			Roots	The whole parts are chopped and then mixed with water to treat Gonorrhea, rabies, anthrax.

2.4. Inoculums preparation. Each bacterial strain was sub-cultured overnight at 35 ^{0}C in an agar plate slant for 24 hrs. Individual microorganisms placed on the plate were grown into individual colonies, each a clone genetically identical to the individual ancestor organism. After the incubation, the colony of the organisms was taken and each was inoculated into 7 ml of peptone water in a bijou bottle and shook vigorously to obtain the solution homogeneity. The turbidity produced by these organisms was adjusted and used to match the turbidity standard prepared as described by [19].

2.5. Antibacterial activity of plant extract. The disk diffusion method is used to evaluate the antimicrobial activity of each plants extract. The plant extracts residues (100 mg) were re-dissolved in 5 ml of methanol, sterilized through a Millipore filter (0.22 mm) then loaded over sterile filter paper discs (8 mm in diameters) to obtain a final concentration of 10 mg/disc. 20 ml of an agar plate medium was poured into sterile petri-dishes followed with 30 ml of seeded medium previously inoculated with bacterial suspension (100 ml of medium/1 ml of 10^7 MPN) to attain 10^5 MPN/ml of medium. Sterile filter paper discs loaded with plant extract concentration of (10 mg/ml) were placed on the top of an agar plate. Filter paper discs loaded with 5 mg of Gentamycin were used as a positive control. The plates were kept in the fridge at 5 ^{0}C for 2 hrs to permit plant extracts diffusion then incubated at 35 ^{0}C for 24 hrs. The existences of inhibition zones were measured with the help of a template and the diameter of the zone of inhibition was determining the effectiveness of the antibiotic. The large diameter indicated the sensitivity of the bacterium to the antibiotic. The zone sizes were compared to a standardized chart to determine the

bacterium sensitivity, resistance, and intermediate sensitivity to that of antibiotics.

2.6. Determination of minimum inhibitory concentrations (MIC's) of the effective plant extract. Minimum inhibitory concentrations (MICs) are the lowest concentration of an antimicrobial that inhibited the visible growth of a microorganism after overnight incubation. The MIC of the selected plant extracts was carried out using a disc diffusion method and evaluating the resistivity of bacterial strains. Different concentrations of the effective plant extracts (100, 20, 4, 0.8, 0.16, and 0.32 mg/ml) were prepared separately by dissolving 200 mg in 100 ml of methanol, sterilized. The most effective extracts of plants that exhibited a strong antibacterial activity at 10 mg/ml were manipulated to determine their minimum inhibitory concentrations. 1 ml of the standardized inoculums from peptone water was then inoculated into the solution in the test tubes. These were all incubated at 37˚C for 24 hrs and observed for turbidity of growth. The lowest concentrations which showed no turbidity in the test tubes were recorded as the MIC.

2.7. Determination of minimum bactericidal concentrations (MBC's) of the effective plant extract. The minimum bactericidal concentration is the lowest concentration of a substance that prevents the growth of an organism after subculture onto antibiotic-free media or the concentration of plant extract that did not exhibit any bacterial growth on the freshly inoculated agar plates. Agar plates were incubated at the temperature of 37 ^{0}C for 24 hours then examined for bacterial growth corresponding to plant extracts concentration.

III. RESULTS AND DISCUSSION

3.1. Plants extraction yield: The ethnobotanical data of the employed plants and their extract percentage yield are illustrated in Table 1. The extract of 100 g of each dried plant material with methanol yielded plant extracts residues ranging from 2.29 to 6.12 g. The highest yield of plant extract was obtained from *Phytolacca dodecandra* (6.12 g) followed by *Drymaria cordota* (4.58 g) while *Celosia tigyna* (2.29 g) give the lowest extract yield, respectively.

Extract yield % = Q/T x 100 (where Q; the weight of extracted plants residues and T; the weight of plant powder).

3.2. Phytochemical Screening: The two extracts were screened for the presence of major phytochemicals using standard qualitative methods as described previously [20-22]. Each plant extracts were screened for the presence of terpenoids, flavonoids, saponins, tannins, alkaloids, fatty acids, steroids, phenols, cardiac glycosides, anthraquinones, and phlobatannis as outlined below:

Test for Phenols: 0.5 ml of the extract, 5 ml of Folin Ciocalteu reagent, and 4 ml of aqueous sodium carbonate were added. The appearance of blue color indicates the presence of phenols.

Test for Saponins: To 2 ml of the extract, 2 ml of distilled water was added and it was agitated in a test tube for 5 minutes. The formation of foams indicates the presence of saponins.

Test for Tannins: 4 drops of 0.1% ferric chloride were added to 2 ml of the extract, a brownish-green or blue-black coloration indicated the presence of tannins.

Test for Alkaloids: To 2 ml of the extract, 2 ml of 10% hydrochloric acid was added. To the acidic medium, 1 ml Hager's reagent (saturated picric acid solution) was added. The presence of alkaloids is confirmed by the formation of a yellow-colored precipitate.

Test for Anthraquinones: 2 ml of the extract was boiled with 5ml of 10% hydrochloric acid for 3 minutes and 5 ml of chloroform was added. 5 drops of 10% ammonia were further added. A rose-pink coloration indicates the presence of anthraquinones or a positive result.

Test for Glycosides: 2 ml of acetic acid was added to 2 ml of the extract. The mixture was cooled in a cold water bath and 2 ml of concentrated H_2SO_4 was then added, color development from blue to bluish-green indicates the presence of glycosides.

Test for Flavonoids: 2 ml of 10% Sodium hydroxide was added to 2 ml of the extract in a test tube. An intense yellow color was formed which turned colorless upon the addition of 2 ml of dilute hydrochloric acid indicating the presence of flavonoids.

Test for Phlobatannins: 2 ml of the extract were boiled with 1% aqueous hydrochloric acid. The formation of a red precipitate indicates the presence of Phlobatannins.

Test for Terpenoids: 5 ml of the extract was mixed in 2 ml of chloroform and 3 ml of concentrated sulphuric acid was carefully added to form a layer. A reddish-brown coloration at the interface indicates the presence of terpenoids.

Test for Steroids: 2 ml of extract were dissolved in 10 ml of chloroform and then 10 ml of concentrated sulphuric acid was added by the side of the test tube. The upper layer turned red whereas the sulphuric acid layer turned yellow with green fluorescence. This indicates the presence of steroids.

The result for the phytochemicals screening tests (analysis) of the methanolic extracts of *Acanthus eminens*, *Celosia*

trigyna, *Drymaria cordata*, and *Phytolacca dodecandra* is shown in Table 2. While Table 3 represents the results for the antibacterial activity of the extracts of the above four selected medicinal plants against the test bacteria.

Table 2: Phytochemical presents in the methanol extracts of Acanthus eminens, Celosia trigyna, Drymaria cordata, and Phytolacca dodecandra.

Phytochemicals	*Acanthus eminens*	*Celosia Trigyna*	*Drymaria cordata*	*Phytolacca dodecandra*
Cardiac glycoside	++	+	-	-
Saponins	+++	+++	+	++
Flavonoids	+++	++	+++	++
Alkaloids	++	+++	+++	+++
Steroids	+	+++	-	+
Terpenoids	+++	+++	-	++
Phenols	++	++	+	+
Anthraquinones	-	+	-	-
Tannins	-	+	+	+

Note: +: slightly present; ++: moderately present; +++: highly present; -: not detected.

The result for the phytochemical analysis is presented in table 2. The result revealed the presence of different phytochemicals in the extract of methanol solvent. The results show that terpenoids, saponins, and flavonoids are highly present, cardiac glycoside, alkaloids, and phenols moderately present, and anthraquinones and tannins not detected in the extracts of stem bark of *Acanthus eminens*. Phytochemicals such as saponins, alkaloids, steroids, and terpenoids are highly present, flavonoids and phenols are moderately present, and cardiac glycoside, anthraquinones, and tannins are slightly present in the extracts of leaves of *Celosia trigyna.* In the leaves extract of *Drymaria cordata*, phytochemicals such as flavonoids and alkaloids are highly present, saponins, tannins, and phenols are slightly present, and cardiac glycoside, steroids, terpenoids, and anthraquinones are not detected. Finally, alkaloids are highly present, saponins, flavonoids, and terpenoids are moderately present, steroids phenols and tannins slightly present, whereas cardiac glycoside and anthraquinones are not detected in the root extract of *Phytolacca dodecandra*. In line with the present study, [23] reported that phytochemicals such as tannins, saponins, flavonoids, and alkaloids are bioactive compounds that have an extensive range of beneficial pharmacological effects like; antimicrobial, antihypertensive, antioxidant, anti-inflammatory, anticancer, and anti-diabetic activities, in addition to alleviating hypercholesterolemia.

3.3. Antibacterial activity of plant extract. Four plant species were investigated to evaluate the antibacterial activity of extracts against pathogenic bacteria including two strains of Gram-positive bacteria (*Bacillus cereus* and *Staphylococcus aureus*) and three strains of Gram-negative bacteria (*Escherichia coli*, *Salmonella typhi*, and *Pseudomonas aeruginosa*) using the disc diffusion method. Evaluation of the antibacterial activity of these plant extracts was recorded in Table 3 and Figure 1. The results revealed that all plant extracts were potentially effective in suppressing microbial growth of pathogenic bacteria with variable potency. *Celosia trigyna* was the most effective extract retarding microbial growth of all Gram-positive and Gram-negative bacteria tested pathogenic bacteria at concentration of 4 mg/ml while extract of *Drymaria cordata* was effective only against *Staphylococcus aureus*. *Phytolacca dodecandra* exhibited an inhibitory effect against four of the pathogenic strains (*Bacillus cereus*, *Staphylococcus aureus*, *Salmonella typhi*, and *Pseudomonas aeruginosa)* whereas *Acanthus eminens* was effective against three of the pathogenic bacteria (*Bacillus cereus*, *Escherichia coli*, and *Pseudomonas aeruginosa*). Results of antibacterial activity of the four plant extracts can be suggested that both *Celosia trigyna* and *Phytolacca dodecandra* plant extracts were the most effective extracts and showed strong antibacterial activity against pathogenic bacteria. The two Gram-negative bacteria (*Escherichia coli* and *Salmonella typhi)* were relatively the most resistant strain to plant extracts whereas two Gram-positive bacteria (*Bacillus cereus* and *Staphylococcus aureus*) and one Gram-negative bacteria (*Pseudomonas aeruginosa*) were the most susceptible strains to the extracted plants. Hence, experiments were conducted to determine their minimal inhibitory concentration (MIC) and minimal bactericidal concentration (MBC) against the most susceptible bacterial

strains (*Bacillus cereus*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*). In coherent with this finding, [24] reported that significant anti-bacterial activity of *C. longa* extract against two pathogenic bacterial strains. The results of MIC and MBC of *C. longa* extract demonstrated promising antibacterial activity of *C. longa* rhizome.

Table 3: Antibacterial screening test of methanolic plants extract (4 mg/ml) against some pathogenic bacteria.

Plant species	Inhibition zones (mm)				
	Gram (+ve) pathogenic bacteria		Gram (-ve) pathogenic bacteria		
	B. cereus	*S. aureus*	*E. coli*	*S. typhi*	*P. aeruginosa*
A. eminens	9.7 ± 0.43	0.0 ± 0.0	12.5 ± 0.54	0.0 ± 0.0	10.7 ± 0.65
C. trigyna	11.2 ± 0.53	17.2± 0.12	14.2 ± 0.34	12.8 ± 0.15	14.3 ± 0.37
D. cordata	0.0 ± 0.0	7.7 ± 0.27	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
P. dodecandra	10.3 ± 0.25	16.7± 0.42	0.0 ± 0.0	11.6 ± 0.13	11.1 ± 0.21
Gentamycin(5mg)	12.6 ± 0.18	19.4 ± 0.21	14.6 ± 0.44	16.5 ± 0.37	11.3 ± 0.29

Data are means of three replicates (n = 3) ± standard error.

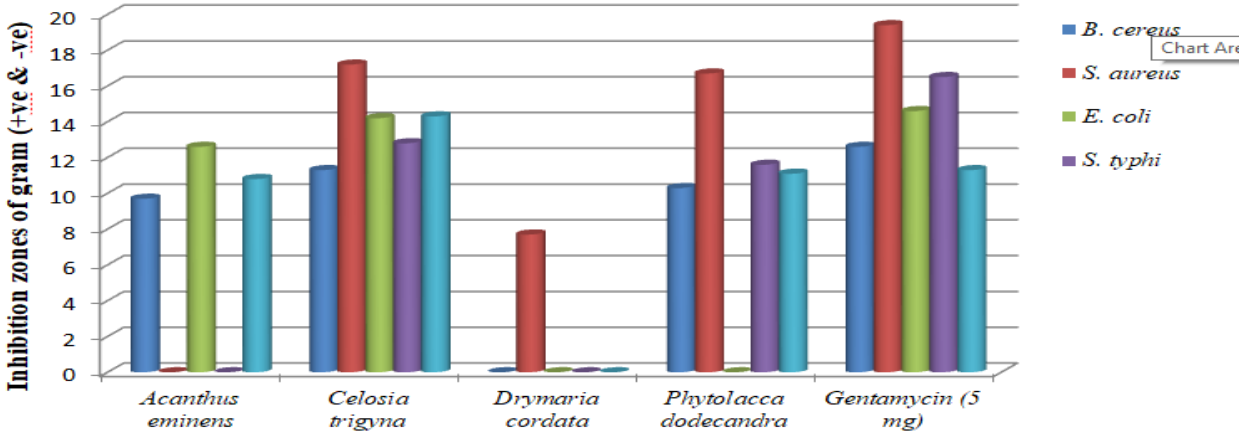

Fig.1: Methanolic plants extract against pathogenic bacteria and positive control.

3.4. Minimum inhibitory concentrations (MIC's) of the effective plant extract. The MIC and MBC of the most effective plant extracts (*Celosia trigyna* and *Phytolacca dodecandra*) were employed by the disc diffusion method to evaluate their bacteriostatic and bactericidal properties. The concentration effect of the effective plant extracts was reported in Table 4 and illustrated in Figure 2. An inhibitory effect of *C. trigyna* extract started at 20 mg/ml with inhibition zones of 8.9, 10.1, and 7.7 mm against *Bacillus cereus*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* while extract of *P. dodecandra* suppressed bacterial growth of these strains at concentration of 0.8 mg/ml with inhibition zones of 16.8, 13.9 and 13.4 mm, respectively. This findings were in accordance with those reported in a work by Jawhari et al. that the inhibition zone diameters of extracts studied ranged from 5.5 to 15.65 mm, and the highest inhibition zone values against pathogens of medical importance such as *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Klebsiella pneumonia* were 15.65, 15, and 15.3 mm, respectively [25].

Table 4: MIC's of the most effective plant extract against Bacillus cereus, Staphylococcus aureus and Pseudomonas aeruginosa.

Plant extract	Conc. mg/ml	Inhibition zones (mm)		
		Gram (+ve) bacteria		Gram (-ve) bacteria
		B. cereus	*S. aureus*	*P. aeruginosa*
C. trigyna	100	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	20	8.9 ± 0.31	10.1 ± 0.95	7.7 ± 0.46

	4	11.6 ± 0.44	17.5 ± 0.23	11.7 ± 0.79
	0.8	19.4 ± 0.86	18.3 ± 0.67	17.1 ± 0.12
	0.16	22.7 ± 0.39	20.5 ± 0.36	19.3 ± 0.23
	0.032	25.9 ± 0.12	24.3 ± 0.91	21.7 ± 0.65
P. dodecandra	100	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	20	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	0.8	16.7 ± 0.85	13.9 ± 043	13.6 ± 0.79
	0.16	18.9 ± 0.13	16.5 ± 0.74	16.3 ± 021
	0.032	20.5 ± 0.46	18.7 ± 0.21	17.4 ± 0.37

3.5. Minimum bactericidal concentrations (MBC's) of the effective plant extract. The minimum bactericidal concentration was confirmed by the absence of bacterial growth of the tested strains streaked from the inhibition zone corresponding to their lowest minimum inhibitory concentrations. *C. trigyna* extract showed potentially bactericidal activity against the tested pathogenic bacteria (*Bacillus cereus, Staphylococcus aureus*, and *Pseudomonas aeruginosa*) with MBC of 4 mg/ml while MBC of *P. dodecandra* extracts reached 0.16 mg/ml except for *Pseudomonas aeruginosa* which was less sensitive and its minimal bactericidal concentration reached to 0.032 mg/ml. The results of MIC and MBC of the effective plant extracts suggested that *Celosia trigyna* and *Phytolacca dodecandra* can be used to control and prevent pathogenic bacteria. *Celosia trigyna* extract suppresses microbial growth of all tested bacterial strains followed by an extract of *Phytolacca dodecandra* which appear to be potentially effective against three bacterial strains or pathogenic bacteria (*Bacillus cereus, Staphylococcus aureus*, and *Pseudomonas aeruginosa*) and less effective against two of them (*Escherichia coli*, *Salmonella typhi*). A great variation in MIC of *Celosia trigyna* extract demonstrated in several investigations may be due to considerable variation in their method of extraction, constituents as well as bacterial strains used. The difference value in minimum inhibitory concentrations of the plant extracts has happened from the variation of secondary metabolites and volatile nature of their constituents. In line with this study, [24, 26], reported that various biological activities of plant extracts are believed to be due to the presence of bioactive compounds. They explained that these plant secondary metabolites are nutritional constituents which are present in very tiny amounts in plants and have the potential for influencing the physiological and cellular activities after consuming them.

Celosia trigyna extract was found to be the most effective with a concentration of (4 mg/ml) against all tested bacterial strains. On the other hand, *Phytolacca dodecandra* extract was found to be effective with a concentration of (4 mg/ml) against *B. cereus, S. aureus, S. typhi*, and *P. Aeruginosa* suppressing their growth with inhibition zones of 10.3, 16.7, 11.6, and 11.1 mm, respectively. These results are in accordance with that of [12, 23]. Some researchers have suggested that antimicrobial components of the plant extracts (terpenoid, alkaloid, and phenolic compounds) interact with enzymes and proteins of the microbial cell membrane causing its disruption to disperse a flux of protons towards the cell exterior which induces cell death or may inhibit enzymes necessary for amino acids biosynthesis [24, 25]. Other researchers attributed the inhibitory effect of these plant extracts to hydrophobicity characters of these plants extract which enable them to react with protein of microbial cell membrane and mitochondria disturbing their structures and changing their permeability. It has been reported that the relationship between a zone of inhibition and MIC values may be greatly affected by the composition of crude extracts that are a mixture of phytoconstituents which may influence the diffusion power of the active constituents, and the different levels of intrinsic tolerance of test strains to antimicrobials which can differ MIC values from one isolate to another [26-28].

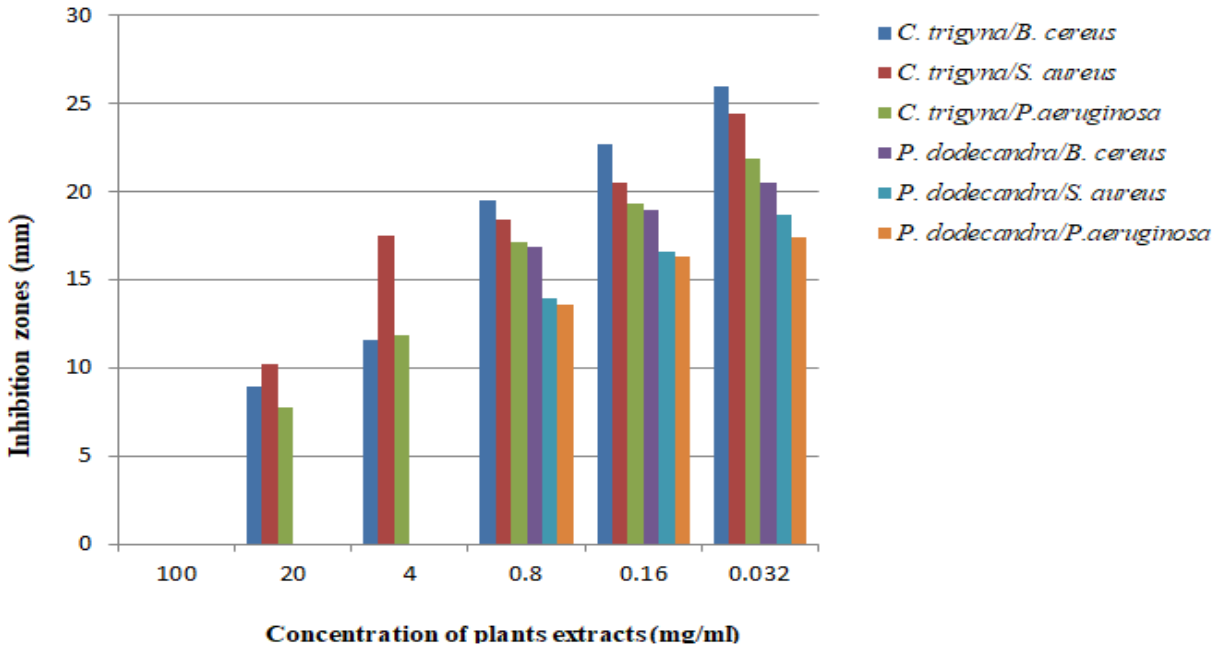

Fig.2: MIC of the most effective plant extract against B. cereus, S. aureus, and P. aeruginosa

In the present study, extracts of *Celosia trigyna* leaves and *Phytolacca dodecandra* roots have the most effective against four pathogenic bacterial strains like *B. cereus*, *S. aureus*, *S. typhi*, and *P. aeruginosa* whereas extracts of *Drymaria cordata* leaves and *Acanthus eminens* stems have indicated practically low activities against pathogenic bacteria. The observed activities of these extracts were relatively similar to other works. Thus, n-butanol leaves extracts of *Cassia angustifolia* exhibited maximum zone of inhibition against *Staphylococcus aureus* (17.0 mm), *Salmonella typhi* (12.0 mm), and *Klebsiella pneumoniae* (10.0 mm); while, methanol extracts have not shown any activity against both the isolates. MICs values of leaf methanol extract of *C. angustifolia* exhibited stronger activity against K. pneumonia and E. coli (0.62 and 1.25 mg/mL, respectively) [29, 30].

Phytochemical Analysis: The HPLC-UV chromatogram of four selected plants Me. Ext is shown in Figure 3. Seven phytochemicals were identified from *C. trigyna* leave; four phytochemicals from *P. dodecandra* root, five phytochemicals from *D. cordata* leave and four phytochemicals from *A. eminens* stem methanol extract when compared to the standard chromatogram. The identified compounds from the HPLC chromatogram as shown in Figure 3 were pheophytin, chondrillasterol acetate, chondrillasterol, carotenoid, lutein, ethinyl estradiol and drospirenone isolated from *C. trigyna* leave methanol extract. Citronellal, cardinene, nerolidol and neryl acetate were isolated from *P. dodecandra* root methanol Extract. Stigmasterol, cerebroside, glucocerebroside, monogalactosyldiacylglycerol and digalactosyldiacglycerol were isolated from *D. cordata* leave methanol Extract. Isopulegol, borneol, caryophyllene and linalool were isolated from *A. eminens* stem methanol extract. The respective peak position, retention time and concentration of identified phytochemicals are given in Table 5.

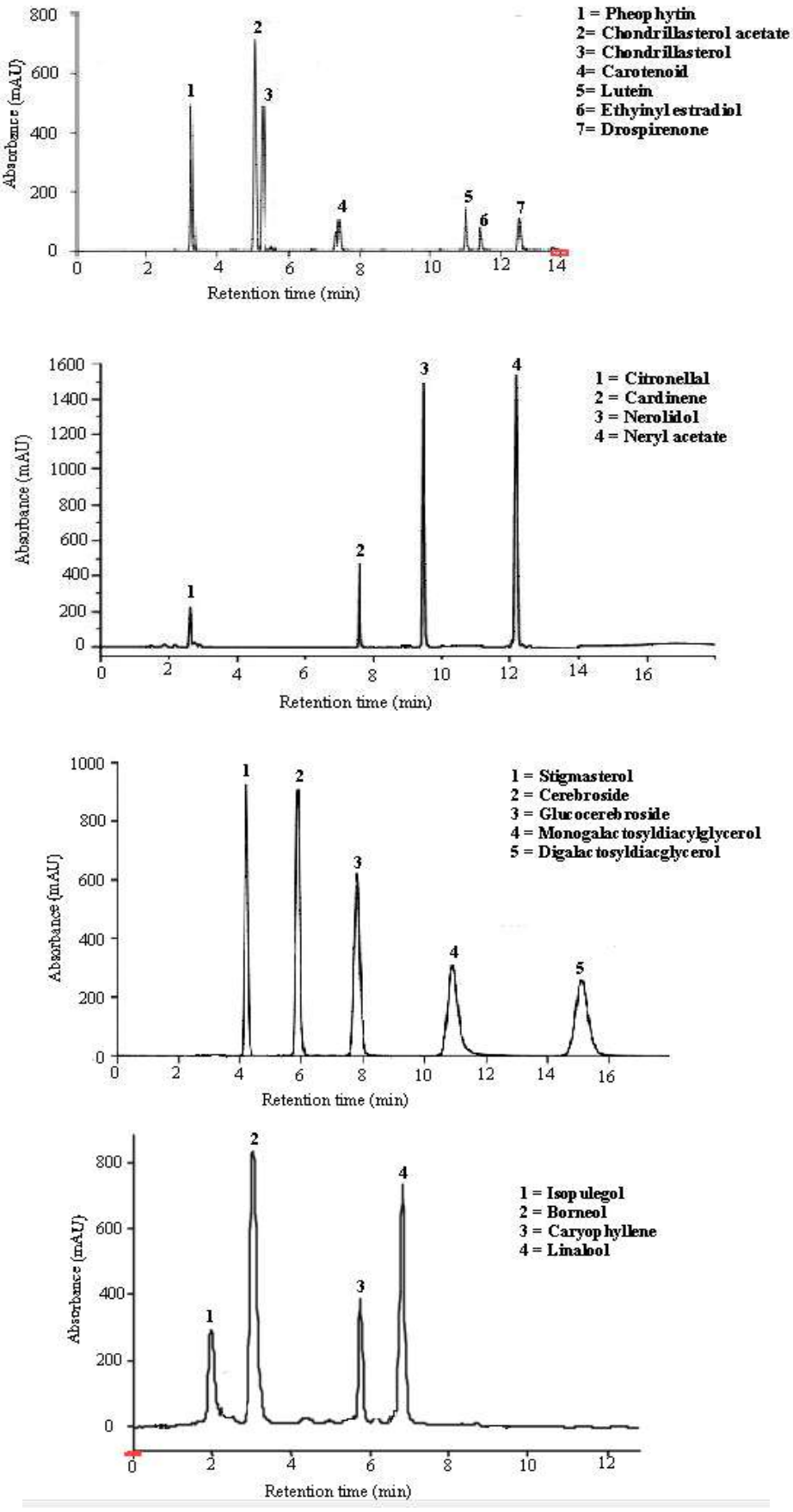

Fig.3: HPLC-UV chromatogram of C. trigyna leave, P. dodecandra root, D. cordata leave and A. eminens stem Me. Ext

Table 5: Identified phytochemicals in C. trigyna leave, P. dodecandra root, D. cordata leave and A. eminens stem Me. Ext.

Peak	Retention Time (min)	Phytochemicals	Peak area	Concentration (µg/ml)
C. trigyna leave Me. Ext				
1	13.54	Pheophytin	7.23	0.5427
2	32.65	Chondrillasterol acetate	2.21	0.0034
3	18.77	Chondrillasterol	0.45	4.3134
4	25.82	Carotenoid	0.68	0.0231
5	10.37	Lutein	0.97	0.7254
6	19.58	Ethinyl estradiol	0.32	1.3125
7	11.54	Drospirenone	0.77	2.7326
P. dodecandra root Me. Ext				
1	11.98	Citronellal	85.06	3.3412
2	24.83	Cardinene	0.78	0.5754
3	25.27	Nerolidol	0.54	0.0043
4	19.21	Neryl acetate	0.75	2.1432
D. cordata leave Me. Ext				
1	16.43	Stigmasterol	5.67	0.7489
2	26.52	Cerebroside	0.69	0.1227
3	12.93	Glucocerebroside	0.34	2.1539
4	11.57	Monogalactosyldiacylglycerol	0.72	0.0856
5	21.34	Digalactosyldiacglycerol	0.89	1.5328
A. eminens stem Me. Ext				
1	11.53	Isopulegol	4.56	5.5321
2	13.25	Borneol	0.48	0.9234
3	20.62	Caryophyllene	0.79	0.0069
4	11.46	Linalool	0.63	1.2954

IV. CONCLUSION

The findings of this study indicate about methanolic extracts of four selected medicinal plants have high potential antibacterial activity against the different pathogenic bacterial strains. This activity supports their use in the treatment of infections caused by such resistant bacteria. The plant extracts which proved to be potentially effective are *Celosia trigyna* and *Phytolacca dodecandra* those can be used as a natural alternative for the treatment of pathogenic microbes, this has led to the search for new antimicrobial agents mainly among plant extracts to discover new chemical structures according to modern phytochemistry. The extract of those two plants has potential antibacterial effects on bacterial strains tested, especially *Bacillus cereus*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. Their antibacterial activity was confirmed by evaluation of both diameters of inhibition zones and minimal inhibitory concentrations.

DATA AVAILABILITY

The data are available from the corresponding author upon request.

DECLARATION OF CONFLICT OF INTEREST

The authors declare that there is no conflicting interest.

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Effectiveness Distribution of Bantuan Pangan Non Tunai Rice (BPNT) through Rumah Pangan Kita (RPK) in the City of Parepare, South Sulawesi Province

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Abstract— *BPNT is food assistance distributed by the government in the form of non-cash to Beneficiary Families (KPM). So to support the implementation of the BPNT program, Perum Bulog provides Rumah Pangan Kita (RPK) as a means of supporting the implementation of the program. The purpose of this study was to determine the process and effectiveness of distributing BPNT rice through RPK in Parepare City.This research was conducted in Parepare City and used a quantitative descriptive method. The research sample used is 27 respondents using the criterion sampling method. The results of this study indicate that the distribution of rice to RPK carried out by Perum Bulog Subdivre Parepare includes activities: Processing orders, warehousing, packaging, and transportation. Activities carried out by staff or sections that have been determined previously. The effectiveness of BPNT distribution is measured based on four indicators of accuracy, namely quality of 65.78%, quantity of 69.78%, time of 41.63% and price of 59.56%. Then it shows that it is at the "fairly effective" level.*

Keywords— ***Bantuan Pangan Non Tunai (BPNT), Effectiveness, Distribution, Rumah Pangan Kita (RPK)***

I. BACKGROUND

Rice is the largest component of food (foodstuffs) for the population, which in addition to it's large number of people, it's growth rate is still relatively high. In addition, the demand and consumption of rice tends to increase from year to year. The government's failure to provide and control the supply of these commodities will certainly trigger social unrest and can be a big problem (Krismiyati et al., 2020).

General Public Corporation (Perum) Bulog is a government agency tasked with controlling price stability and maintaining price stability for staple foods, especially at the consumer level (Anindya, 2016). Perum Bulog has two tasks, namely public duties and commercial tasks. In public duties, Perum Bulog carries out government assignments, namely business activities to provide goods/services needed by the community, while Perum Bulog's commercial duties seek to earn some profits from product sale.(Karo, 2015).

The duties of Perum Bulog as a Public Company, the pillars of food defense in Indonesia, are twofold, namely public service or Public Service Obligation (PSO) and commercial (Budianto, 2020). The commercial section is the sales department that pays attention to the company's profit or profit by selling food products to the public directly with distribution networks including, Toko Pangan Kita (TPK), Rumah Pangan Kita (RPK) and Food SOEs (Mufidah, 2017). Meanwhile, the PSO's duties include securing basic food prices, managing government food reserves and distributing staple foods to certain groups of

people. In fulfilling the PSO task, Perum Bulog distributes rice stock for the Government Rice Reserve (CBP), Regional Movement and National Movement and provides BPNT rice stock which will be distributed to people in need (Hermanto, 2018).

Bantuan Pangan Non Tunai Program (BPNT) is one of the important social assistance provided by the government to reduce the burden of spending on poor households in accessing some of their food needs (Hermawan et al., 2021). Bantuan Pangan Non Tunai (BPNT) is carried out in a non-cash form from the government which is given to KPM every month through an electronic account mechanism that is used only to buy food at food traders/e-warong in collaboration with banks (Rachman et al., 2018). Bantuan Pangan Non Tunai Program (BPNT) started in 2018 in the City of Parepare. There are 4 sub-districts that receive Bantuan Pangan Non Tunai Program (BPNT) that have access to adequate facilities. Before being known as the BPNT Program, this program was often known to the public as Raskin Program (Beras Miskin) which has several problems on it's program (Ardiyani, 2021).

Perum Bulog as the manager is responsible for the running of BPNT Program, from the procurement of food ingredients to the distribution of food subsidy assistance to distribution points. To support this program, the government has prepared Rumah Pangan Kita (RPK) in each region as a means of supporting the implementation of the program. Perum Bulog will continuously increase the number of Rumah Pangan Kita (RPK) in each region to maximize service, especially for BPNT distribution (Fetiningrum, 2017).

Rumah Pangan Kita (RPK), which is a cooperation partner as well as a food distribution network that is fostered directly by Perum Bulog with price stabilization activities and government program services (Yulia, 2019). Food products sold through RPK such as rice, sugar, oil, flour, meat, etc. to achieve access to basic food for the community (Triputro, 2020). RPK is also one of the distribution intermediaries between Bulog and the community. One of them is being a place for distributing BPNT rice to be given to people in need or KPM. The official RPK developed by Perum Bulog Subdivre Parepare has been running for about 4 years. Through the RPK, it is hoped that KPM can easily take BPNT rice in a timely manner and of good quality. In addition, Bulog hopes that the distribution will be more efficient and affordable for KPM (Damanik et al., 2014).

The implementation of the BPNT Program must refer to several indicators of success, namely the first, proper quality, namely the quality of the food distributed must have good quality standards, suitable for consumption, odorless, lice and yellow in color. Second, the amount of rice received must be in accordance with what is determined by the government. Third, the price for BPNT must be the same as the price set by the government. Fourth, the time for distributing rice must be on time to the RPK location (Sari et al., 2019).

Although the presence of the RPK is able to facilitate Perum Bulog in distributing BPNT rice, the reality in the field is that the implementation process is still experiencing many problems, one of which is in terms of timeliness and not in accordance with the distribution plan. There are often delays in receiving rice to RPK due to the limited number of vehicles and vehicle capacity, thus making the community in this case the KPM late to receive their assistance and often blame the RPK. Therefore, it is very important to distribute BPNT rice effectively in Parepare City to reduce the burden of spending on community food needs and provide balanced nutrition to KPM.

Many previous studies have discussed the effectiveness of distributing Raskin (Srikandi & Ardini, 2018), the level of effectiveness and efficiency of distribution of Raskin (Ekafitri et al., 2014), effectiveness and efficiency of distribution of poor rice in Trienggadeng District (Septian et al., 2013), how to analyze the effectiveness and efficiency of the distribution of rice for the poor in Helpano Village (Rifal, 2016), How is the effectiveness of Rastra distribution in Sedinginan Village? (Febrianti, 2019), (Sani et al., 2015) the Raskin distribution system in Medan City and analyze the effectiveness of the Raskin distribution, (Siddik Pohan et al., 2018) discusses the level of effectiveness of rice distribution for the poor in the West Bilal area

The seven studies discussed the effectiveness of the distribution of the Raskin program in different places and used different analytical methods. However, this research only focuses on the effectiveness of distributing Raskin. Research that discusses the effectiveness of BPNT rice distribution through Rumah Pangan Kita (RPK) is still very limited and can be said to be non-existent. In addition to knowing how effective the distribution of BPNT rice in Parepare City is based on four indicators. This study also wants to know the process of distributing BPNT rice carried out by Perum Bulog through Rumah Pangan Kita (RPK). Based on this, the researcher wants to raise the title of the research regarding "**Effectiveness of Distribution of Bantuan Pangan Non Tunai Rice through Rumah Pangan Kita in Parepare City**".

II. FORMULATION OF THE PROBLEM

Rumah Pangan Kita (RPK) is a program from Bulog that collaborates with the community with the aim of maintaining price stability and becoming a staple food

stock. In addition, RPK is also a distributor of BPNT. Bantuan Pangan Non Tunai (BPNT) is still relatively new so that in the implementation process there are still many problems, one of which is in terms of timeliness where the timing of the distribution of rice to KPM is not in accordance with the distribution plan, there is a delay in the distribution. This is because the delivery of rice from Perum Bulog to the RPK location is sometimes not on time. This problem is one of the things that is often faced by RPK located in Parepare City. This is because the vehicles owned by distributors are still very limited and also require a long packing time. Based on the formulation of the problem, the topics to be discussed in this study are:

1. How is the process of distributing Bantuan Pangan Non Tunai (BPNT) rice through Rumah Pangan Kita (RPK) in Parepare City?
2. How effective is the distribution of Bantuan Pangan Non Tunai (BPNT) rice through Rumah Pangan Kita (RPK) in Parepare City?

2.1 Research purposes

Based on the description of the research problem formulation, the objectives of this research consist of:

1. Knowing the process of distributing Bantuan Pangan Non Tunai (BPNT) rice through Rumah Pangan Kita (RPK) in Parepare City.
2. Knowing how effectivedistribution of Bantuan Pangan Non Tunai (BPNT) rice through Rumah Pangan Kita (RPK) in Parepare City.

2.2 Research Use

1. For Perum Bulog: This research is used as a source of evaluation and supervision to be able to assessthe effectiveness of BPNT rice distribution activities so that distribution activities can run smoothly and in accordance with previously designed plans.
2. For Researcher : This research can be a new knowledge and experience regarding matters related to the effectiveness of product distribution and distribution process.
3. For Academics: This research can be used as a reference material for further research so that it can add intellectual insight that is used to scientifically study the effectiveness of rice distribution.

2.3 Framework

Bulog is one of the State-Owned Enterprises called BUMN in the form of a Public Company where one of its business fields is in the field of food logistics management, by prioritizing the function of Public Service Obligations (PSO) to ensure the availability, stability of staple food commodities and affordability. The implementation of the Public Service Obligation (PSO) service from the government, namely the management of the Government Rice Reserve (CBP) and the distribution of Bantuan Pangan Non Tunai Program (BPNT).

Bantuan Pangan Non Tunai Program (BPNT) is an innovation or new method carried out by the government regarding the distribution of food assistance which is carried out conventionally in the form of providing food product assistance in the form of rice to KPM and channeled through Perum Bulog. So to support the programThe government prepares Rumah Pangan Kita (RPK) which is a cooperation partner or distribution network for selling staple foods owned by the community, which is fostered directly by Perum Bulog. In addition, Rumah Pangan Kita (RPK) is also a distributor of the BPNT program, namely rice. In implementing the BPNT Program, it must refer to the indicators of success, namely : the quality of the distributed rice must be fit for consumption, odorless, lice, and broken. Second, the amount of rice received by KPM is in accordance with what is set by the government which is 10 kg of rice/period. Third, the BPNT redemption price that has been set must be the same as the price redeemed by the KPM. Fourth, the distribution of rice must be on time. So, with these four elements, the BPNT Program in Parepare City can be known whether it is effective or not.

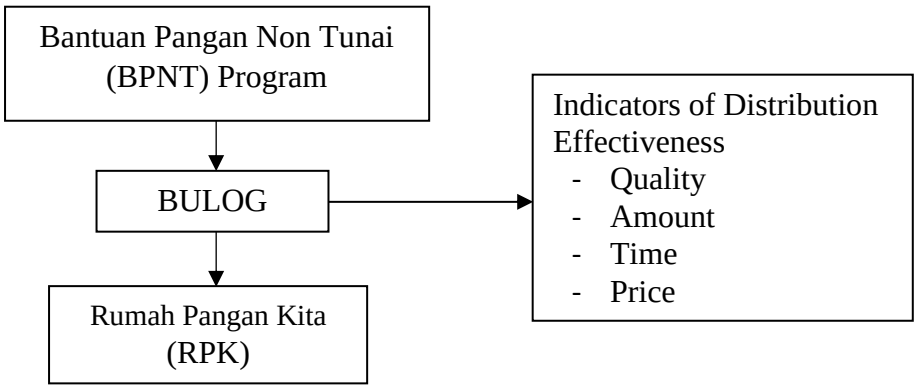


Fig.1. Schematic Framework of Thinking

III. RESEARCH METHODS

3.1 Research sites

To obtain data as material to answer the problems that have been raised, this research was carried out in the City of Parepare, South Sulawesi Province with the time of the study being carried out in May-June 2022.

3.2 Research methods

The research method used is descriptive quantitative. According to (Mukhtar, 2013), quantitative research is a systematic scientific study of the parts and phenomena and their relationships. The purpose of quantitative research is to develop and use mathematical models, theories and hypotheses related to natural phenomena or in accordance with what is happening in the field. The measurement process is a very important part and needs to be considered in quantitative research because it provides an overview or answer to the fundamental relationships of quantitative relationships (Hardani, S.Pd. et al., 2017).

3.3 Analysis Method

According to (Moleong, 2011), data analysis is what is done by working with data, organizing data, sorting it into manageable units, synthesizing it, looking for and finding patterns, finding out what is important and what is learned and deciding what to tell others. The data obtained were analyzed using appropriate analytical methods and tools. To answer the second objective, namely to determine the effectiveness of the distribution of Bantuan Pangan Non Tunai (BPNT) rice through Rumah Pangan Kita in Parepare City, it was carried out using the TCR formula.

3.3.1 Determination of TCR Value

To determine the level of respondent's achievement on the effectiveness of BPNT rice distribution through RPK in Parepare City, the following formula was used :

$$TCR = \frac{Average\ Score}{Maximum\ Score} x\ 100\%$$

The criteria for the effectiveness of distributing BPNT rice through RPK in Parepare City based on four indicators are described in table 1.

Table 1. TCR Classification

No.	Achievement Percentage	Criteria
1.	85% - 100%	Very effective
2.	66% - 84%	Effective
3.	51% - 65%	Effective enough
4.	36% - 50%	Less effective
5.	0% - 35%	Ineffective

Source: Arisandi (2016)

3.3.2 Calculating the Average (Mean)

According to the mean or mean is a typical value that represents the nature of the center or the center position of a set of data values. The arithmetic mean or often called the mean is denoted by X. The arithmetic mean for ungrouped data is formulated as follows:

$X=\frac{X1+X2+\cdots+Xn}{n}$

Or

$$X = \frac{\sum xi}{n}$$

Information :

X = Average

X = Data value

n = Lots of data

The average score obtained is used to categorize the perceived effectiveness into: not effective (< 3.0), moderately effective (3.0-3.5) and very effective (> 3.0), Frequency, percentage and standard deviation used to analyze the data.

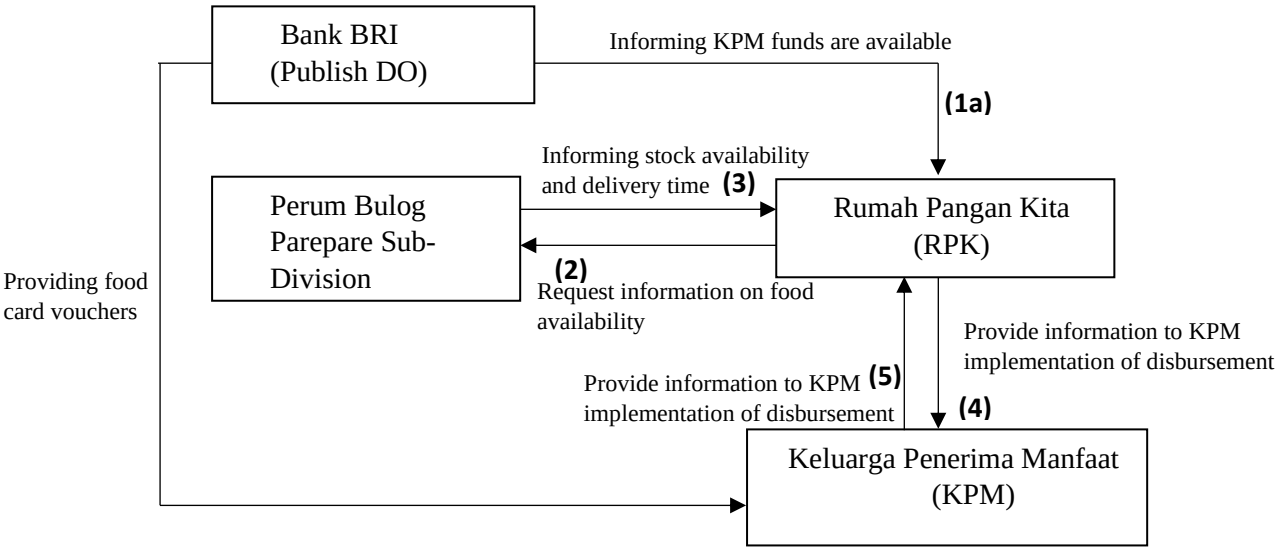
IV. RESULTS AND DISCUSSION

4.1 Bantuan Pangan Non Tunai Program (BPNT)

The President of the Republic of Indonesia at the Limited Cabinet Meeting (Ratas) regarding the program to reduce poverty and economic inequality in 2016 has given directions that in the 2017 budget the distribution of Raskin benefits is carried out through electronic cards (e-vouchers). Through the direction of the President of the Republic of Indonesia, the Ministry of Social Affairs coordinates with Perum Bulog and Bank BRI to innovate the provision of assistance to Beneficiary Families (KPM), namely by changing the Rastra Program into a Bantuan Pangan Non Tunai Program (BPNT).

In the BPNT Program there were changes in the type, volume of food received by KPM, the number of recipients,

prices, food providers and there were changes in the distribution method and the involvement of other parties such as Bank BRI and Rumah Pangan Kita (RPK) in Parepare City. In the process of distributing BPNT, the data on beneficiaries that have been determined by the Ministry of Social Affairs has been agreed upon by the regional government and Bank BRI. Bank BRI issues a DO (Delivery order) letter to RPK. After receiving a DO (Delivery Order) letter, RPK placed an order for rice to Perum Bulog. Then Perum Bulog carried out preparations starting from processing orders to packaging rice carried out by the commercial section to delivering to each RPK location in Parepare City. After the food is distributed to the RPK, the community can conduct transactions for disbursement of food aid in the RPK.



Picture. 2 BPNT Distribution Flow

To see the effectiveness of BPNT distribution, it can be assessed through measuring the success of the BPNT program as follows:

1. Right Quality: Fulfillment of quality requirements of rice distributed in accordance with Bulog's rice quality standards, namely 10 kg of premium rice
2. Appropriate Quantity: The amount of rice distributed by Perum Bulog Subdivre Parepare is in accordance with the number of orders made by RPK.
3. On Time: Estimated delivery time of rice is carried out in accordance with the distribution plan that has been determined by the RPK and in coordination with the Ministry of Social Affairs.
4. Right Price: The price of rice paid by RPK to Perum Bulog is in accordance with that set by the government

4.2 Effectiveness of BPNT Rice Distribution through RPK

Bantuan Pangan Non Tunai Program (BPNT) is a replacement program for Rastra. The implementation of BPNT Program in Parepare City has been going on since the beginning of 2018, where the program is a form of assistance to the poor community provided by the government with an amount of RP.110,000/month which can be disbursed into staple foods, namely rice and eggs. Perum Bulog Subdivre Parepare is a provider of BPNT commodities, in various e-warongs or RPKs in Parepare City. Perum Bulog Subdivre Parepare in this case only provides food commodities, namely rice, although it also produces other food commodities such as variants of our flour, our sweet sugar, cooking oil, etc.

To support the implementation of the BPNT program, Perum Bulog provides Rumah Pangan Kita (RPK) as a means of supporting the implementation of BPNT program. RPK is a sales outlet that collaborates with Bank BRI as a place to make purchases and exchanges by KPM using food card vouchers that have been distributed. RPK is found in every sub-district in Parepare City that has been selected to implement the BPNT program. This is done by the government to support the success of the distribution of assistance that is easily accessible by KPM.

The Regional Government and Perum Bulog Subdivre Parepare play a full role in the aid distribution process. The role of Perum Bulog Subdivre Parepare is very important in the process of distributing aid, starting from the preparation of distribution to the implementation report. In the process of distributing the BPNT Program there is also involvement from other parties, namely Bank BRI. The government cooperates with Bank BRI as a provider of food card vouchers and serves as the issuer of Delivery Orders (DO) to Perum Bulog Subdivre Parepare and coordinates with RPK managers in food distribution activities. The distribution of food materials is directly distributed by

Perum Bulog to the RPK location. Where is RPK as a distribution point that is easily accessible by the community located in all sub-districts in the City of Parepare.

Bank BRI and RPK play the role of implementing aid distribution in the field which directly interacts with the beneficiary communities. This is different from the previous Raskin program where the process of distributing food aid is fully carried out by the State Logistics Agency (Bulog) Subdivre Parepare. The media used in distributing food aid in the BPNT program uses electronic media, namely a swipe machine or EDC (Electronic Data Capture) machine and food card vouchers. Unlike the previous rastra program, to distribute aid using a manual method, namely by providing assistance directly to distribution points whose locations are determined and agreed upon by Perum Bulog and the Government.

In determining an effectiveness in a program that has been run, of course, several indicators of success are needed. Similar to the BPNT program run by RPK, the success of the program is measured based on the level of achievement of indicators, namely, right quality, right quantity, right time and right price.

4.2.1 Precise Quality

The right quality is that the rice sent by Perum Bulog is fit for consumption. The BPNT rice quality standard that has been set by Perum Bulog Subdivre Parepare in 2017 is 15% premium rice.

Table 3.Percentage of RPK Answers to the Right Quality Indicators

No.	Alternative Answer	Score	Number of Respondents	Percentage
1.	Strongly agree	5	3	11.12%
2.	Agree	4	15	55.55%
3.	Neutral	3	9	33.33%
4.	Don't agree	2	0	0%
5.	Strongly Disagree	1	0	0%
Total			**27**	**100%**

Source: Primary data processed, 2022

Based on the table above, it can be seen that the majority of respondents, namely RPK, have a fairly good assessment of the product quality provided by Perum Bulog in the BPNT program. This can be seen in table 2, 11.12% strongly agree with the rice quality indicator, 55.55% agree with the rice quality from Perum Bulog, and 33.33% do not really rely on the quality of rice provided by Perum Bulog. The type of rice distributed for BPNT program is 15% premium rice weighing 10 kg per sack. The quality standards set in this 15% premium rice are 13-15% water content, 13-15% broken, 95% polishing degree and pH 6-7. Quality greatly affects the feasibility of a product to be consumed. This is in line with the opinion (Bilgies, 2017) which states that product quality is a determining factor for consumer satisfaction after making a purchase and use of a product. With good product quality, the desires and needs of consumers for a product will be fulfilled. Therefore, Perum Bulog has maintained the quality of their products well by utilizing existing facilities and infrastructure. This is evidenced by the quality of the rice distributed to the RPK of good quality, the rice is white and has a fragrant aroma in accordance with community expectations.

4.2.2 Exact Quantity

The exact quantity is the amount of rice received by the RPK in accordance with what was delivered, namely in 10 Kg packages. The percentage of the quantity accuracy indicator is as follows:

Table 4. Percentage of RPK Answers to Quantity Appropriate Indicators

No	Alternative Answer	Score	Number of Respondents	Percentage
1.	Strongly agree	5	7	25.93%
2.	Agree	4	15	53.55%
3.	Neutral	3	5	18.52%
4.	Don't agree	2	0	0%
5.	Strongly Disagree	1	0	0%
Total			**27**	**100%**

Source: Primary data processed, 2022

Based on the table above, most of the respondents said the quantity of BPNT rice distributed by Perum Bulog was in accordance with the order or delivery order (DO) that had been made previously. This is evidenced by the appropriate number of products that have been ordered and delivered to the RPK (Rumah Pangan Kita). The quantity of the product is determined by the number of KPM around the neighborhood and registered in the RPK. Therefore, there is no rice or product left during the BPNT distribution process. In addition, the packaging of 10 Kg is considered very sufficient to meet the needs of KPM for one month.

4.2.3 On time

The timeliness indicator is the estimated time of delivery of rice carried out in accordance with the distribution plan that has been determined by the RPK and in coordination with the Government. The Social Service has implemented it with the aim that the distribution of the BPNT program can run according to the specified time so that there is no delay in the distribution of aid.The percentage of timeliness of distribution is as follows:

Table 5. Percentage of RPK Answers to Timely Indicators

No	Alternative Answer	Score	Number of Respondents	Percentage
1.	Strongly agree	5	6	22.21%
2.	Agree	4	7	25.93%
3.	Neutral	3	7	25.93%
4.	Don't agree	2	7	25.93%
5.	Strongly Disagree	1	0	0%
	Total		**27**	**100%**

Source: Primary data processed, 2022

Based on the table above, most of the respondents said that there was often a delay in the delivery of BPNT rice to the RPK. This is because after RPK ordered rice, Perum Bulog did not immediately deliver the rice. Perum Bulog has a rice package of 50 Kg, so it takes 1-2 days to deliver the rice because it needs to be packaged in a 10 Kg package. After that, it will be delivered to the location of the RPK. So that the process of distributing BPNT rice can run effectively.

4.2.4 Right Price

The indicator of price accuracy is the price of BPNT rice given to RPK in accordance with a predetermined price of Rp. 8,300/Kg. The percentage of price accuracy is as follows:

Table 6. Percentage of RPK Answers to the Right Price Indicator

No	Alternative Answer	Score	Number of Respondents	Percentage
1.	Strongly agree	5	2	7,41%
2.	Agree	4	11	40.74%
3.	Neutral	3	10	37.04%
4.	Don't agree	2	4	14.81%
5.	Strongly Disagree	1	0	0%
	Total		**27**	**100%**

Source: Primary data processed, 2022

Based on the table above, 12 out of 27 respondents agreed that the price of rice given by Perum Bulog to RPK was in accordance with the provisions of the government, namely Rp. 9.300/Kg. However, there are situations that can cause price shifts such as instability in the amount of stock or rice stocks in the market. If the supply of rice in the market decreases, the company decides to increase the price in order to get a bigger profit and vice versa if the supply increases, the company will reduce the price so that the stock of rice owned does not accumulate.

Table 7. Effectiveness of BPNT Rice Distribution

No.	Indicator	Effectiveness					Amount	Total Score	Average Score	TCR (%)	Category
		Frequency (person)									
		STS	TS	N	S	SS					
1	Precise Quality	0	0	9	15	3	27	444	16.44	65.78	Effective
2	Exact Quantity	0	0	5	15	7	27	471	17.44	69.78	Effective
3	On time	0	7	7	7	6	27	281	10.41	41.63	Less effective
4	Right Price	0	4	10	11	2	27	402	14.89	59.56	Effective enough
	Total							**1598**	**59.19**	**236.74**	

Source: Primary data processed, 2022

Based on the table above, it was obtained data that the effectiveness of BPNT rice distribution through RPK in Parepare City was around 65.78% stating it was effective about the quality of rice distributed by Perum Bulog to RPK, then 69.78% said it was effective about the amount of rice delivered to RPK locations, then 41.63 % stated that it was less effective regarding the delivery time of rice to RPK locations and 59.56% stated that it was quite effective regarding the price of rice given by Perum Bulog to RPK.

The distribution of BPNT program in the City of Parepare only met two indicators of accuracy, namely the right quality and the right quantity and did not meet the two indicators of accuracy, namely on time and right price. Meanwhile, BPNT rice distribution program through RPK has the benefits and objectives of increasing the timing of receiving food aid, being closer to the community, providing balanced nutrition for KPM recipients, and providing food that is easily accessible, quality, diverse and inexpensive. However, the target of on time delivery and the price given to RPK has not been achieved, so that BPNT rice distribution program has not run smoothly even though it has been quite long, namely 4 years and still requires some attention from Perum Bulog Subdivre Parepare. This is in line with the opinion of Sedarmayanti in (Klas & Manado, 2018) which says that effectiveness is a measure that gives an idea of how far the target has been achieved. So it can be concluded that the effectiveness in distributing BPNT rice in Parepare City is quite effective, this can be seen from the fulfillment of the three indicators of distribution effectiveness, namely the right quality, right quantity and right price. Meanwhile, there is only one indicator that has not been fulfilled, namely the timeliness of rice distribution. This is in accordance with research Meanwhile, there is only one indicator that has not been fulfilled, namely the timeliness of rice distribution. This is in accordance with research Meanwhile, there is only one indicator that has not been fulfilled, namely the timeliness of rice distribution. This is in accordance with research(Risnandar & Broto, 2018) which explained about the implementation of BPNT was concluded to be successful with several indicators of success.

V. CLOSING

4.1 Conclusion

Based on the results and discussion obtained in this study, the following conclusions can be drawn:

1. The implementation of the food distribution process includes various activities such as, Bank BRI issues a DO (Delivery order) letter to Perum Bulog Subdivre Parepare. After receiving a DO (Delivery Order) letter, Perum Bulog carried out preparations starting from processing orders to packaging rice carried out by the commercial department as the executor of distribution in the field to delivering to each RPK location in Parepare City.
2. The effectiveness of BPNT program rice distribution by Perum Bulog is measured in four precise indicators, namely quality, quantity, time and price. Based on these four indicators, indicators whose implementation has been effective, namely the right quality and quantity are categorized as effective (65.78% and 69.78%), while on time are categorized as less effective (41.63%) and the right price is categorized as quite effective (59.56%).

4.2 Suggestion

Based on the conclusions above and from the results of research that has been done. The author provides

suggestions or input that can be used as consideration in the distribution of the Non-Cash Food Aid program, including:

1. It is hoped that Perum Bulog Subdivre Parepare will make more use of RPK as a distributor of BPNT rice distribution so that the distribution process can be more efficient and more planned so that beneficiaries get good service.
2. It is hoped that Perum Bulog Subdivre Parepare pays attention to and maintains the quality and quantity of BPNT rice to be distributed as well as efficient, price and timely distribution of BPNT rice.

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Utilization of Biochar as organic fertilizer for Seedling growth of *Zea mays* (Maize)

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***Abstract*—** *The seedling growth of maize, their germination rate and seedling length were ascertained using biochar pyrolyzed at temperatures between 400-550°C. All the biochar used were alkaline and contained mineral-rich components such as; C, Ca, O, K, Na, Mg, Si, Al, that could enrich the soil and as well treat acidic soil. Also all the biochar produced are good for planting. However, biochar pyrolyzed at 400°C gave the maximum seedling growth length. The germination rate was between 75%-100%. Biochar produced at 400° C was significantly (P <1.000) greater than SDB450. There is no significant difference between SDB450 and SDB500 (P < .461), also no significant difference between SDB 550 and control (P < .192 at a 95% level of significance. Biochar utilization could be a promising way of reducing the negative environmental effect of fertilizer.*

***Keywords*— Biochar, pyrolysis, seedling growth, biomass, sawdust.**

I. INTRODUCTION

Food security is one of the recent issues discussed globally. Sustainable strategies and methods are required to sustain the growing population's demand for food. Crop yields can be greatly improved by the application of some useful practices and methods such as increasing organic fertilizer use efficiency (Yang *et al.*, 2017; Lu *et al.*, 2014). The use of fertilizer has proved to be beneficial but it is usually accompanied by some environmental negative effects such as; nitrate leaching, groundwater pollution, river, lake, and coastal water eutrophication. Constant use of fertilizer in order to solve the rising human demands may lead to a consequential effect of accumulating huge environmental costs (Claudia *et al.*, 2015). Thus, an eco-friendly, renewable alternative or complementary approach capable of reducing the negative impact of fertilizer as well as enhance plant growth and promote soil carbon sequestration is of great interest. Biochar has received significant interest in the literature, mostly for its ability to improve soil quality and sequester carbon (Klasson, 2017). Biochar is a solid product obtained from the thermochemical conversion of biomass in an oxygen-limited environment (IBI, 2012). This process of thermochemical decomposition of biomass produces biochar, bio-oil, and syngas.

Biomass can be of plant and animal origin such as sawdust, rice husk, pea nut shell, cow dung, palm kernel. Sawdust is a waste biomass from forest resources (Timber). These wastes are not properly managed and thus constitute to environmental pollution. Sawdust wastes are transformed to useful resources through pyrolysis to improve the economy as well as solve the problem of pollution. During pyrolysis, moisture and volatile materials are lost leaving behind a solid carbon-rich, fine-grained porous structured material with aromatic surface and different functional groups (Lee *et al* ., 2017). Biochar has a high specific surface area, high amounts of oxygen-containing functional groups, and high stability (Huang *et al.*, 2016). This unique nature of this pyrogenic carbon material (biochar) offers its applications in areas such as agriculture, climate change, environmental remediation, energy (Tan *et al.*, 2017; Wang *et al.*, 2018; Zhou *et al.*, 2017), and soil amendment. Biochar has contributed positively to the agricultural sector to improve

plant growth owing to its porosity and sorption capacity, liming capacity, the improvement of soil fertility, and water holding capacity. Biochar is very recalcitrant and can contribute to climate change mitigation by carbon sequestration and reduction of agricultural emissions of CO_2, N_2O, and CH_4 (Hagemann *et al.*, 2017).

Biochar obtained and its application depends on the feedstock and pyrolysis condition (Enders *et al.*, 2012). The biochar obtained from relatively low-temperature pyrolysis possess a high content of volatile matter which contains labile compounds that decompose easily within a short period which affects plant growth positively (Jindo *et al.*, 2014; Liu *et al.*, 2014), while the structure of biochar produced at high -temperature pyrolysis has a large surface area and contains aromatic-carbon which may increase the adsorption capacity and recalcitrant character (Jindo *et al.*, 2014; Ahmad, 2012). Such biochar is usually employed for environmental bioremediation and carbon sequestration; which directly removes carbon dioxide from the atmosphere. (Jindo *et al.*, 2014; Lehmann, 2007). The stability of biochar in the soil is higher with increased pyrolysis temperature (Purakayastha *et al.*, 2015).

Several investigations have been reported on the effect of biochar on plant growth. Berihun *et al.*, (2017) reported that biochar application on soil significantly affected the soil bulk density, porosity, pH, and exchangeable acidity which resulted in (95.23%) maximum germination percentage observed in the garden pea seeds at 18 t ha^{-1} of Lantana biochar. Hagemann *et al.*, (2017) reported in their study that biochar promotes plant growth, especially when combined with nutrient-rich organic matter, e.g., co-composted biochar. Adding char to soil has been found to increase crop yield, increase water retention, and to increase soil stability. Moreover, it releases carbon much more slowly than biomass left on the field and thus contributes to carbon sequestration (Dupont and van Hullebusch, 2018). Claudia *et al.*, (2015) reported the greatest positive plant responses observed with mineral-rich biochars made from manure and straw on the application of large doses (> 10 t ha−1 biochar) at once.

The aim of this research involves the utilization of biochar from sawdust biomass to enhance maize seedling growth.

II. MATERIALS AND METHODS

Biochar was produced through slow pyrolysis at different temperatures between 400-550 ºC at Forest Reserve Institute Malaysia (FRIM). The pH, EDX and Zeta potential of the biochar produced were determined.

2.1 pH value

The pH of biochar was determined in a mixture of 1 g biochar and 20 mL deionized water. The mixture was stirred using a magnetic stirrer for 1 h and allowed to stand for 10 mins. The pH level was measured with a pH meter (JENCO Vision Plus 6175-3C).

2.2 EDX

The elemental analysis of biochar were observed with a scanning electron microscope (HITACHI FESEM SU8220) equipped with an energy dispersive X-ray (EDX) spectrometer and X-max detector (oxford – instruments). The sample was mounted on the SEM stub using carbon tape and inserted into the chamber, at accelerating voltages between 10-20 kV and 2,500-10000 times magnification.

2.3 Zeta potential

Biochar powder (20 mg) was dispersed in 200 ml of distilled water to make a suspension in a conical flask. The conical flask was shaken at 150 r/min for 12 h, and the zeta potential of biochar in the suspension was measured using a Zeta Potential Analyzer (Malvern zeta sizer) (Hong *et al.*, 2019).

2.3 Germination test.

Biochar was used to monitor the germination rate and seedling growth of maize following the method reported by Marmiroli *et al.*, (2018) with modification. Biochar samples were sieved to pass through a 250 µm mesh. A dilute solution of methanol was dabbed in cotton wool and was used to clean Petri dishes to kill any bacteria present in them and to remove impurities as well as sanitize the Petri dishes. A ball of fresh small cotton wool was placed on the Petri dishes which were used as soil. 0.5 g of dried sieved biochar at different pyrolytic temperature were placed on the cotton wool in triplicate biological analysis. 3-4 seeds of maize were sown on each petri dish in a triplicate biological analysis followed by the addition of 10 mL of distilled water to each of the Petri dishes and were kept in the dark to germinate. After three days the germinated seeds were counted and their root length was measured daily until the tenth day and the germination rate percent was calculated.

Germination rate % = (number of germinated seeds/number of starting seeds) ∗ 100 (1)

III. RESULTS

3.1 pH value

The pH results of biochars displayed in Table 3.1, indicate the level of alkalinity of biochar at different pyrolytic temperature. The result shows that the biochars produced in this study are alkaline.

3.2 EDX

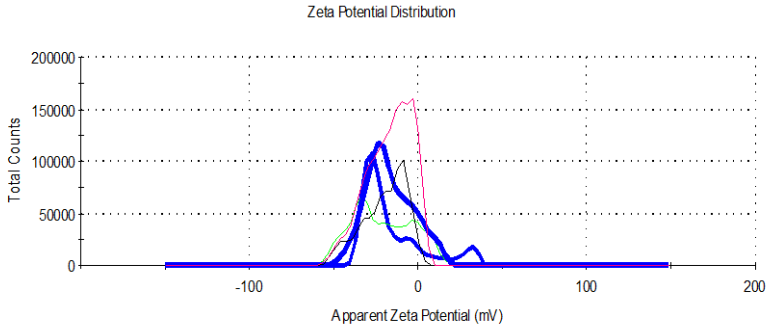
EDX of sawdust biochar is shown in Fig.3.1. The presence of mineral-rich components such as C, Ca, O, K, Mg, Si, P, and Al, enriched the biochar.

Table 3.1: EDX analysis (Elemental analysis (wt %)) and pH sawdust biochar

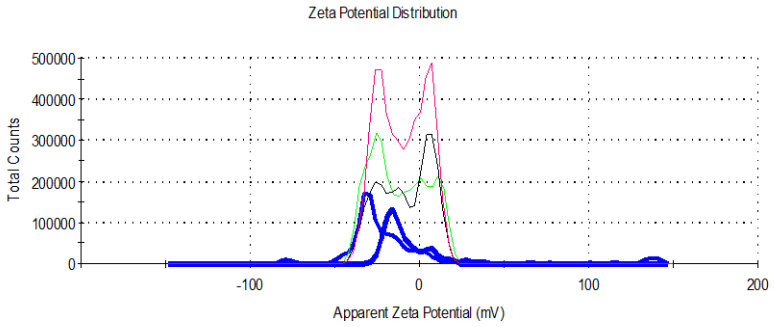
sample	C	O	Mg	K	Ca	Si	P	Al	pH
SDB 400	74.02	14.71	0.49	2.94	0.98	3.92		2.94	7.94
SDB 450	92.16	16.24	0.58	1.14	0.39		0.17		8.6
SDB 500	92.42	11.32	0.22	0.7	0.29	0.06	0.06		9.1
SDB 550	94.09	4.88	0.15	0.33	0.33	0.18			9.22

3.3 Zeta potential of SDB biochar

The zeta potential obtained was negative for all the biochar samples as shown in Fig.3.1. The zeta potential of SDB450 at pH 8.6 was -16.9 mV and became slightly less negative at SDB500 with increasing pH (8.9) -14.8 mV.



SDB450



SDB500

Fig. 3.1 Zeta potential of SDB450 and SDB500

3.4 Effect of biochar on seedling growth and germination rate

Effect of biochar on seedling growth test was performed by placing seeds of maize on cotton wool in the presence of sawdust biochar of different temperatures in water. The effect is measured by taking into account the number of seeds that germinated and the seedling growth length after 3 days of planting compared to the control and also their seedling length after 10 days of planting as shown in Fig.3.2

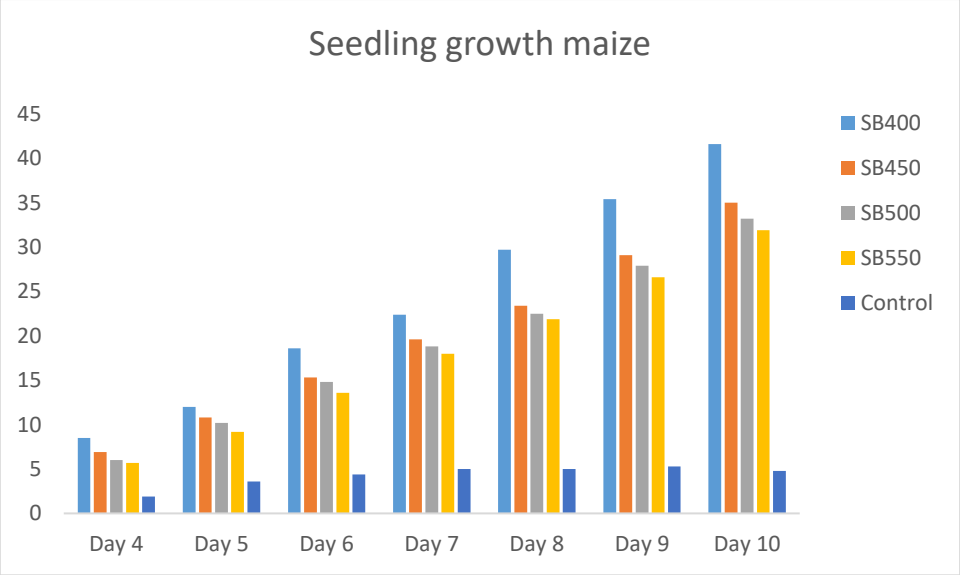


Fig.3.2. Effect of biochar at different temperatures on seedling growth maize

Fig.3.3 Optical images of images of seedling growth of maize plant

3.5 Statistics analysis for seedling growth of Maize

The means and standard deviation of seedling growth of maize results for each day of analysis of different samples are presented in Table 3.2. The results show that SDB400 has greater mean values than other biochar samples.

Table 3.2 Descriptive Statistics for seedling growth of Maize

	Biochar	Mean	Std. Deviation	N		Biochar	Mean	Std. Deviation	N
Fourth day	Control	.708	.6680	12	Eighth day	Control	3.575	1.6466	12
	SB400	5.575	.3888	12		SB400	23.533	1.4067	12
	SB450	2.000	.9909	12		SB450	8.192	2.8234	12
	SB500	1.217	.5859	12		SB500	7.508	1.5246	12
	SB550	.842	.8404	12		SB550	4.267	1.6555	12
	Total	2.068	1.9550	60		Total	9.415	7.5642	60

Fifth day	Control	2.183	1.5608	12	Nineth day	Control	3.408	1.4607	12
	SB400	10.025	.8013	12		SB400	28.233	1.8802	12
	SB450	4.008	1.4126	12		SB450	8.767	2.9724	12
	SB500	3.583	1.0125	12		SB500	8.458	1.4600	12
	SB550	2.375	1.1323	12		SB550	4.733	1.7500	12
	Total	4.435	3.1322	60		Total	10.720	9.2755	60
Sixth day	Control	2.917	1.6694	12	Tenth day	Control	2.708	1.4068	12
	SB400	14.433	1.2565	12		SB400	33.158	2.1441	12
	SB450	6.017	2.2230	12		SB450	9.358	3.0938	12
	SB500	5.567	1.2146	12		SB500	9.017	1.2855	12
	SB550	3.342	1.3846	12		SB550	5.225	1.9429	12
	Total	6.455	4.4757	60		Total	11.893	11.1888	60
Seventh day	Control	3.833	1.9099	12					
	SB400	19.100	1.0863	12					
	SB450	6.983	2.4094	12					
	SB500	6.883	1.4390	12					
	SB550	4.050	1.5413	12					
	Total	8.170	5.9169	60					

IV. DISCUSSION

4.1 pH value

The results displayed in Table 3.1, indicate the level of alkalinity of biochar at different pyrolytic temperature. The result shows that the biochars produced in this study are alkaline. It was observed that as the heat treatment temperature (HTT) increases, the pH value also increases as shown in Table 3.1. Sawdust biochar at 550^{o}C indicated pH of 9.10. Similar result has been reported by Mary *et al.*, (2018). Biochar pH values between 3.1 and 12.0 have been reported in the literature. During pyrolysis, most of the acidic functional groups are removed and salts of alkali and alkaline earth elements become enriched. These indicate that biochar has the potential to neutralize soil acidity. Biochar can serve as a good liming agent to increase the pH of acidic soil and the availability of nutrients for various types of soil (McElligott et al., 2011). Phosphorus is often tightly bound in soils rich in Fe and Al oxides, but with the addition of biochar, the soil pH is increased, thereby making phosphorous more available to plants and microorganisms (Marmiroli et al., 2018).

4.2 Zeta potential of SDB biochar

The zeta potentials in the pH range of 8-9 were obtained for SDB at 450^{o}C and 500^{o}C pyrolytic temperature using Malvern zeta sizer. The zeta potential obtained was negative for all the biochar samples as shown in Fig. 3.1. The zeta potential of SDB450 at pH 8.6 was -16.9 mV and became slightly less negative at SDB500 with increasing pH (8.9) -14.8 mV. The negative values of the zeta potentials of biochar at all pH suggest that the surfaces of biochar are negatively charged. This may be due to the presence of a higher amount of OH-containing functional groups in SDB. However, the negative charge of the biochar surface decreases with an increase in pyrolysis temperature (Hong *et al.*, 2019). This may likely be due to deprotonation of the functional group which makes the surface of the biochar negatively charged which is consistent with the findings of Samsuri *et al.*, (2014) reported. The negative charges across the surface of biochar help in the immobilization of heavy metals such as Cd^{2+} and protect plants especially biochar produced at high temperatures (Hong *et al.*, 2019).

The detection of alkali metals of Na, K, Ca, and Mg by EDX shows that biochar is alkaline in nature and also it is a clear indication that alkali metals cannot volatilize during the pyrolytic process (Chen *et al.*, 2016).

4.3 EDX

The presence of mineral-rich components such as; C, Ca, O, K, Fe, Na, Mg, Si, Al, are found in the biochar structure as displayed in Table 3.1, similar metals have been reported by (Purakayastha *et al.*, 2015). This is an indication that there are some oxides in the biomass which could not be volatilized and in turn, enriched the biochar leading to their application in soil enhancement and plant growth. The results indicated that pyrolysis displayed different impacts on the elemental composition of sawdust biomass.

4.4 Effect of biochar on seedling growth and germination rate

Effect of biochar on seedling growth test was performed by placing seeds of maize on cotton wool in the presence of sawdust biochar of different HTT in water. The effect is measured by taking into account the number of seeds that germinated and the seedling growth length after 3 days of planting compared to the control and also their seedling length after 10 days of planting. Seeds (3-4) of each of the selected plants sown in each petri dish grew on the fourth day of planting and maintained good seedling growth for ten days. It was observed that all the biochar samples improved plant growth as displayed in Fig.3.2. Biochar produced at pyrolysis temperature between 400-550^{o}C can improve plant growth. The germination rate was between 75%-100% SDB550, and control which had 75% while others had a 100% germination rate. All other seeds germinated and grew very well and their length was measured until the tenth day of planting. However, biochar produced at 400^{o}C (SDB400) showed maximum seedling growth. This is due to volatile matter and easily labile content present in it which decomposed easily and affects plant growth positively, followed by 450^{o} C, 500^{o}C, and 550^{o}C. Therefore, biochar produced at low temperature has more potential to retain fertilizer cations such as NH_4^+ and thereby improve their utilization efficacy. The control which has no treatment only cotton wool and water also grew but not comparable with biochar. Although it was withering after the seventh day.

4.5 Statistical Analysis

The means and standard errors of the biochar produced at 400^{o}C was higher and have relatively lesser standard deviation compared to other biochar at 450, 500 and 550^{o}C. Biochar produced at 400^{o} C was significantly (P <1.000) greater than SDB450. There is no significant difference between SDB450 and SDB500 (P < .461), also no significant difference between SDB 550 and control (P < .192 at a 95% level of significance.

V. CONCLUSION

This study has shown that slow pyrolysis of biochar can improve plant growth positively. Biochar produced at a pyrolytic temperatures between 400 and 550^{o}C are good for planting. However biochar produced at 400^{o}C showed maximum plant growth. The Overall seedling growth is as follows; SDB400>SDB450>SDB500 >SDB550. Biochar produced at 400^{o} C was significantly (P <1.000) greater than SDB450. There is no significant difference between SDB450 and SDB500 (P < .461), also no significant difference between SDB 550 and control (P < .192 at a 95% level of significance.

Thus biochar used in this study enhanced maize seedling growth. Therefore, biochar is considered to have great potential for enhancing plant growth and also improves soil quality without negative environmental effects; such as leaching, groundwater pollution, and water eutrophication.

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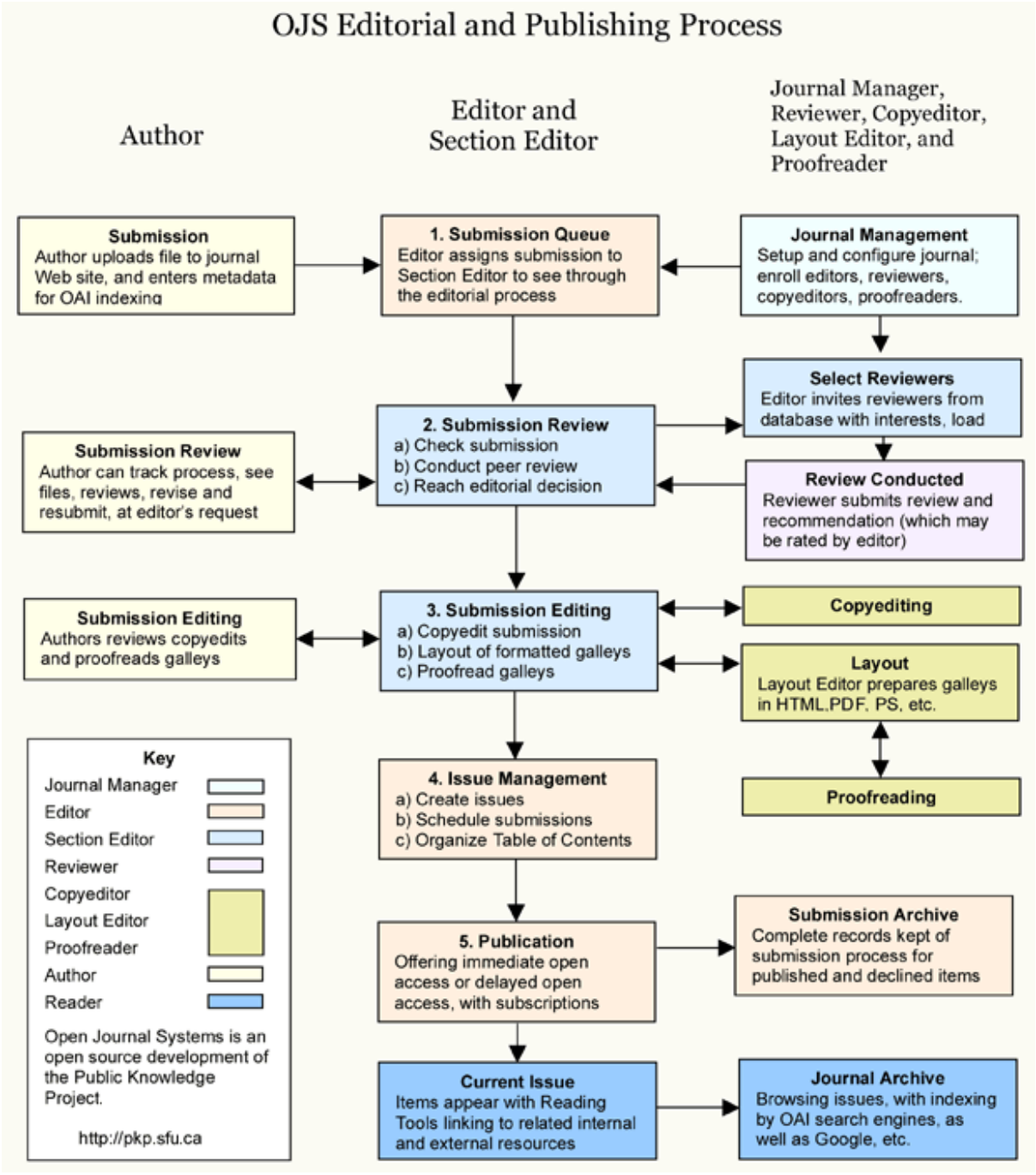

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