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Role of Phytogenic Feed Additives in Swine Production- A Review

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***Abstract*—** *Continuous research is being carried out to attain higher productivity with the available resources since several decades. Feed additives comprising of probiotics, prebiotics, acidifiers, immune modulators, buffering agents, ionophores etc. though are in vogue,in addition to antibiotic growth promoters(AGP), advancement is being aspired through the way of herbs and their products which are called as Phytogenic feed Additives (PFA) or simply Phytobiotics. PFA are said to be having positive effects in improving the performance of poultry and swine. Many reports say that PFA increase the dry matter intake probably due to an increased palatability of the feed.PFA is said to have anti microbial and anti oxidant properties. In addition, PFA have shown to improve the endogenous enzyme secretion, stimulation of appetite, improving the digestibility and absorption of nutrients and also promote the proliferation of beneficial bacteria like Lactobacillus spp. A ban on the use of AGP leads to explore the use of herbs and their products like extracts and residues. Herbal residues are the left over's remained after the active principle is extracted. Reports say that extraction efficiency (%) ranges from 88-97 for different methods. Some of the residues showed considerable anti bacterial property at 2% levels during the Minimum Inhibitory Concentration tests. The use of PFA is restricted to commercial preparations and results are available only for these works, there needs a systemic approach to explain about the function of these PFA in terms of type and dose of each additive. However long term studies will be of added advantage proving the efficacy of these PFA,their safety for animal health and their availability widely in nature. The aim of this review is to explore and explain the multifaceted properties of PFA in terms of elimination of gut pathogens improving the digestibility and palatability and thus enhancing the overall production of the animal.*

Keywords*— *Feed additives, PFA, performance, pathogen inhibition, nutrient digestibility.

I. INTRODUCTION

Any nutrient fed to the livestock is meant for its productivity and the accountability for this nutrient is fulfilled only when it is used to the maximum extent. Proteins and energy, the major nutrients are of critically important and these provide energy to the livestock on metabolism. But there are certain non-nutrient substances used in animal nutrition for getting the better quality of feed, better quality livestock products, for better availability of nutrients in the gut, and also for improving the gut health. Feed additives are the non-nutrient substances which come under this category. Common feed additives used in animal diets include probiotics, prebiotics, immune modulators, antimicrobials, anti oxidants, enzymes, pH control agents, flavonoids in addition to antibiotic feed supplements

There is increasing pressure for livestock producers to minimize the use of antibiotics as growth promoters in food animals. There is a ban on the use of most of the antibiotic feed additives within the European Union in 1999, a complete ban enforced in 2006, due to a speculated risk of generating antibiotic-resistance in pathogenic bacteria.

Some discussion on other feed additives

Prebiotics have been described as non-digestible oligosaccharides which selectively stimulate the growth of favourable species of bacteria in the gut, thereby benefitting the host. Because they are not digested and absorbed by the pig, they provide readily available substrates for the normal bacteria to grow. Fructo-oligosaccharides (FOS), Mono-oligosaccharides (MOS) and inulin are the best examples that have been used as prebiotics.

Probiotics are live microbials supplemented in pig diets that can beneficially affect the host animal by improving the microbial balance in the gut.Probiotics commonly used include*Lactobacillus acidophilus*, *Enterococci faecium*, *Bacillus* species, *Bifidobacteriumbifidum*, and the yeast *Saccharomyces cerevisiae*. As feed additives, they are supplemented in diets to improve the balanceof bacteria in the gut.

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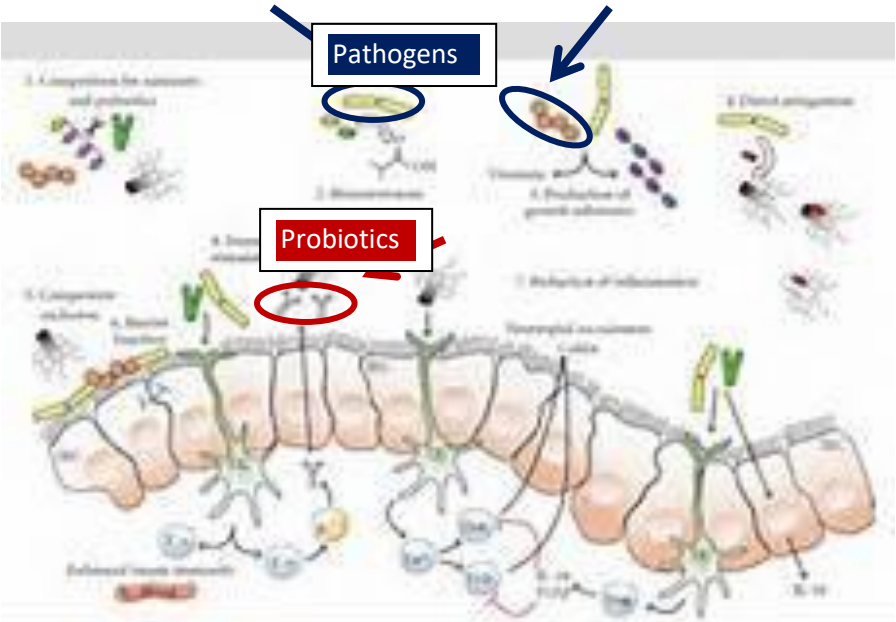
The proposed benefits from probiotics are improved digestion, stimulation of gastrointestinal immunity and increased resistance to infectious diseases of the gut. Probioticsalso changes the permeability of the mucous membrane and increase the nutrient uptake and thus improve the growth performance.



Binding of probiotic organisms to the intestinal mucosa

Anotherimportant feed additivesare the antibiotic growth promoters (AGP).These are the substances which are produced by the living organisms (molds, bacteria, fungi or green plants) and which have bacteriostatic /bacteriocidal properties. In addition to their feed addition as growth promoters, antibiotics are used as nutritional stimulants to promote better feed efficiency in ruminants and swine and to increase the egg production, hatchability and shell quality in poultry. They are also added to the feed in substantially higher quantities to remedy pathological conditions. Since there is a ban on the use of AGP in the farm animals to improve the productivity and health status by the European Union and US, the use of other feed additives have come into force.

Other feed additives include those which influence feed stability, those which modify animal growth, which feed efficiency, metabolism and performance and those which modify consumer acceptance. Antifungals, antioxidants, pellet binders, acidifiersfeed flavours, buffers, immune modulators, xanthophylls etc all come under these categories. In spite of very good results obtained using these additives, they are still not comparable to those obtained using antibiotic growth promoters and research is still very actively looking for new alternatives to combat the increased potential for bacterial disease development in growing pigs especially under conditions of average management quality.All these additives either improve the keeping quality of the feed or increase the feed intake and most of them have no role in the nutrient utilization from the feed in the gut. For the nutrients to be utilized to the maximum they have to be attached to the gut mucosa for absorption and utilization.But this sometimes gets minimized due to the presence of pathogenic organisms which compete with the nutrients for absorption cites in the gut mucosa. In this process, some of the nutrients will be eliminated from the gut due to lack of sites. Hence there should be some additive which eliminates the pathogens from the gut and this is to say that the additive should have antibacterial property. Antibiotic feed additives belong to this category. With the introduction of Aureomycin in 1949 as a growth promoter, sub-therapeutic dosage of antibiotics in animal feed has been generalized all over the world and has produced important benefits in productive performance and in the prevention of pathologic processes (Anderson *et al.*, 1999). However after five decades of usage, concerns about bacterial resistance have become an important issue. Since there is a ban on the use of these antibiotics, alternates in the form of Phytogenic feed additives are being explored.

What are Phytogenic feed additives

Phytogenic feed additives (often also called ‘phytobiotics’ or ‘botanicals’) are commonly defined as plant-derived compounds incorporated into diets to improve the productivity of livestock through amelioration of feed properties, promotion of the animals’ production performance, as well as improving quality of food derived from those animals.

Herbs, their residues and plant extracts (PE) are one of the oldest additives used by mankind. However during the 20th century, they are left apart because of the production of synthetic drugs. Recently doubts about

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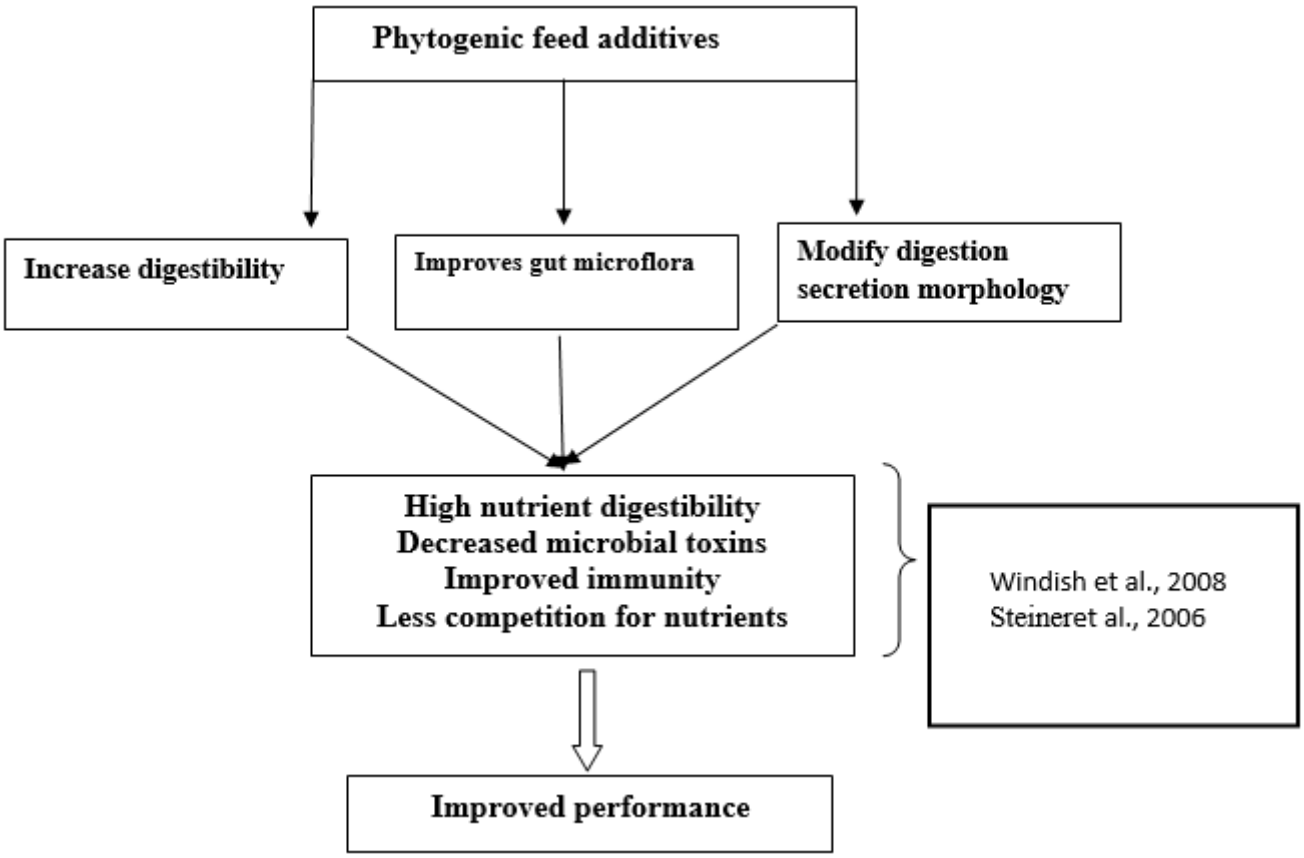
safety of some synthetic drugs, especially antibiotics, have allowed the growth of new interest on the so-called natural products i.e., herbs and plant extracts. These are termed as **Phytogenic feed additives**(often also called 'phytobiotics' or 'botanicals') which are commonly defined as plant-derived compounds incorporated into diets to improve productivity of livestock through amelioration of feed properties, promotion of the animals' production performance, as well as improving quality of food derived from those animals.

Whole herbs contain many active principles used to treat diseases and relieve symptoms. Herbal medicine (botanical medicine), uses the plant's seeds, berries, roots, leaves, bark or flowers for medicinal purposes. Many factors like the type of environment in which the plant grows, the harvesting method of the herb and the way in which the herbal plant is processed influence the efficiency of an active principle. Maceration with solvents like water, alcohol and other solvents will also affect the efficiency of an active principle to work.

Schematic diagram on the various functions of phytogenic feed additives



Probable functions of Phytogenic feed additives

These feed additives explored after a ban on certain additives is said to have antimicrobial (Guo et al, 2004 a), antioxidant (Hahemi et al, 2009 a), anti-stress (Chattopadhyaya et al,2005), gut flora multiplication (Hahemi et al, 2009 b)and immune enhancement (Guo et al, 2004 b) and over and above feed intake is increased. Photogenic feed additives also comprises of a wide variety of herbal residues, spices and products derived thereof. The mode of action of plant active substances include improvement of the endogenous enzymes secretion, stimulation of appetite, improving the digestibility and absorption of nutrients, promote proliferation of beneficial bacteria like *Lactobacillus* species in the gut.

Anti microbial property

Many reports say that these feed additives have antibacterial /anti microbial property which is depicted by the inhibition of many pathogenic bacteria in the gut (Chizzola et al, 2005; Newman et al, 2000; Cowman 1999;Baratta et al, 1999; Namkung et al, 2004). It was also reported that these improve the post weaning performance in pigs (Sulabo et al., 2010).Anti microbial effect is due to the elimination of pathogenic bacteria in the gut and thus making the nutrients more available to the animals and thus improves the performance. This property is mainly attributed to the presence of essential oils in the medicinal plants. Oregano and Thyme are the main essential oils which gained interest in this regard.

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In general, phytogenic feed additives have a strong antibacterial and to some extent antifungal properties. They inhibit the growth of *Escherichia coli*, *Proteus sp*, *Staphylococci*, *Streptococci* and *Salmonella* (Aruoma*et al.,* 1996; Benencia and Courreges, 2000; Garcia *et al.,* 2003) which otherwise compete with the host for nutrients.

The antimicrobial property was attributed to the hydrophobicity (Newbold *et al*., 2004) of plant extracts which facilitates their union to the bacterial surface inducing unstabilization (Tsuchiya *et al.,* 1996; Zhang and Lewis, 1997) or the inactivation of different molecules of the bacteria such as enzymes or receptors through their union to the specific site(Mohammadi et al 2015 a & b).

Residues of Ginger, Emblica and Turmeric were used in the swine rations (Suryanarayana, 2010) and has reported maximum inhibitory effect on pathogenic bacteria in the gut was shown by Ginger followed by Turmeric and Emblica. The antibacterial effect in gut pathogens was in the order of ginger > turmeric >amla.

These products are used in animal production as alternatives to AGP because of their antimicrobial properties. However, many other different effects have been reported such as changes in immune function (Boyaka*et al.,* 2001), enzyme stimulation (Platel and Srivasan, 2000), antiparasitic (Force *et al.,* 2000), antifungal (Mahmoud, 1994), antiviral effects (Aruoma*et al.,* 1996; Benencia and Courreges, 2000; Garcia *et al.,* 2003), anti-toxigenic activity (Sakagami*et al.,* 2001) and antioxidant activity (Dorman *et al.,*2000 ;Teissedre and Waterhouse, 2000). Concerning digestive function, they have important effects upon secretions and motility of the stomach and intestine. Given the enzymatic limitation of the piglet at weaning and also the limited ability of the pigs to digest dietary fibre, these products may be beneficial in improving the digestive capacity of pigs.

Emblicaofficinalis (Synonym, Phyllanthusemblica) has been known to have antioxidant, hepatoprotective and immunomodulation effects (Bandyopadhyay*et al.,* 2000; Sai Ram *et al.,* 2002).

Ginger (*Gingeberisofficinale*) has strong antibacterial and to some extent antifungal properties. *In vitro* studies have shown that active constituents of ginger inhibit multiplication of bacteria in colon. These bacteria ferment undigested carbohydrates causing flatulence. It inhibits the growth of *Escherichia coli, Proteus spp*, *Staphylococci*, *Streptococci* and *Salmonella.* The ginger extract has antimicrobial action at levels equivalent to 2000 mg/ ml of the spice. Ginger inhibits aspergillus, a fungus known for production of aflatoxin, a carcinogen. Fresh ginger juice showed inhibitory action against *Asperigillu sniger*, *S.cerevisiae*, *Mycodermaspp.*.and *L. acidophilus* at 4, 10, 12 and 14% respectively, at ambient temperatures, respectively (Windisch*et al*., 2008)

Turmeric (*Curcuma longa*) is a well-known indigenous herbal medicine. It's major constituents, curcumin, various curcuminoids, curcuma oil – particularly dl-ar-turmerone – exhibit a wide range of biological activities like anti-bacterial (Windisch*et al*., 2008), anti-inflammatory, hypolipidemic, hepatoprotective, lipoxygenase, cycloxygenase, protease inhibitory effects, besides being effective active oxygen scavengers and lipid peroxidase inhibitors.

Antibacterial activity (Inhibition zone, mm) of herbal residues (Suryanarayana, 2010)

Herbal residues	*Escherichia coli**	*Staphylococcus aureus**	*Salmonella typhimurium**	*Bacillus cereus**	*Campylobacter jejuni*	*Listeria monocytogenes**	*Streptococcus pyogenes**	*Methicillin resistant Staphylococcus aureus***
Emblica Officinale	18.00 ^{b} ± 1.15	19.33 ^{b} ±0.33	13.33 ^{b} ±0.33	14.00 ^{b} ±1.15	13.00 ± 0.58	16.67 ^{b} ±2.33	12.00 ^{b} ± 0.00	13.00^{c} ± 0.57
Curcuma longa	21.00 ^{ab}±2.31	25.00 ^{ab} ±2.88	22.00 ^{ab}±3.46	12.00 ^{b} ±1.15	13.00 ± 0.58	21.00 ^{ab} ±1.73	18.00 ^{ab}±2.31	18.66 ^{b} ±0.68
Gingiber Officinale	26.00 ^{a} ±1.15	30.67 ^{a} ±3.48	24.33 ^{a} ±3.48	18.00 ^{a} ±1.15	13.00 ±1.15	25.00 ^{a} ± 1.15	20.33 ^{a} ± 4.09	22.67 ^{a} ± 1.21

^{abc} values in a column not sharing common superscripts differ significantly ** (P<0.01) * (P<0.05)

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Name of the herb	Properties identified		
	Antioxidant	Anti viral	Anti bacterial
Black mustard	4	4	5
Clove	3	--	--
Coriander	7	12	20
Cumin	5	7	11
Garlic	9	5	13
Ginger	6	6	17
Oregeno	14	11	19
Thyme	4	3	5
Turmeric	3	3	5

Some of the phytogenic feed additives with number of active principles identified

Antioxidant property

The extracts from the phytogenic plants (herbs & spices) are said to have Anti-oxidative properties (Wei and Shibamoto, 2007). Among a variety of plants the volatile oils from the *Labiatae* family have drawn more interest. These anti oxidant feed additives will prevent the auto oxidation of the cells preventing the cell damage and (Miguel,2010) protects the feed lipids also from cell damage. It was reported that these feed additives protect the cells on par with the feed added antioxidants like tocopheryl acetate or butylated hydroxytoluene (**BHT**).

Some information on herbal residues

Herbal residues are the left over remained after the active principle is extracted which is the most common method of getting out the active principle. Generally the organizers follow 2 methods of extraction-(i) until equilibrium exists between drug components and solvent (decoctions, tinctures etc) (ii) extraction of active principle to exhaustion (until all solvent extractables are removed. Extraction efficiency (%) for different methods range from 88-97 and in no case extraction is percent (Chemiloids Pvt Ltd).

Residues o*f Curcuma longa, Emblicaofficinale and Gingeberisofficinale*were able to inhibitthe pathogenic bacteria *Viz- Escherichia coli, Staphylococcus aureus, Salmonella typhimurium, Bacillus cereus, Campylobacter jejuni, Listeria monocytogenes, Streptococcus pyogenes,* Methicillin resistant *Staphylococcus aureu* . These residues were able to inhibit the pathogenic bacteria at 2% level during the studies by Minimum Inhibitory Concentration (MIC) tests (Suryanarayana, 2010). Feeding diets containing herbal residues reduced ($P<0.01$) the Coliform, Staphylococci and Salmonella in the gut of swine (Suryanarayana et al, 2010)

During *in vitro* studies conducted by (Suryanarayana et al, 2010) it was reported that *Zingiberis* residue was effective in inhibiting the growth of pathogens. It was observed that herbal residues are able to check the growth of bacteria during fermentation. Higher Organic matter fermentation, higher acetic acid production, lower pH could be the probable reasons for a lower bacterial count in T_4, since these factors can arrest the growth of undesirable bacteria especially *Salmonella*. It is well known that the presence of the SCFA will lead to a drop in pH that can have a negative effect on some potentially pathogenic bacteria (Williams et al., 2005). It has also been shown that SCFA inhibit the growth of *Salmonella* (Van derwiele, 2001). VFA can have an antibacterial effect, thereby preventing the establishment of pathogenic bacteria, such as *Salmonella* spp. (Cummings and Englyst, 1987).

The growth of *Salmonella*, a gram-negative bacterium and more dreadful communicable from humans to animals and vice-versa is checked with certain of the Phytogenic feed additives as mentioned here under…

Extract of *Schezandra efluctus* is effective against 13 strains of *Salmonella* (Zaika, 1988)

Golden seal fights against harmful bacteria especially *Salmonella*

Allian, (from garlic oil) checks *Salmonella* (Johnson and Vanght, 1969)

Turmeric (*Curcuma Longa*) contains curcuma and curcuminoids (phytochemicals) guard the stomach by killing *salmonella* (Vitaminstuff.com)

(Windisch *et al*., 2008) *In vitro* studies have shown that Ginger extract (2000 mg/ml) inhibits *E. coli, Proteus spp. Staphylococcus, Streptococcus* and *Salmonella*.

Emblica officinalis (active principle) inhibits pathogenic bacteria Coliforms, Staphylococcus and Salmonella in gut of monogastric animals (Bandyopadhyay *et al*., 2000)

Ginger residue inhibits pathogenic bacteria in the gut followed by turmeric and amla suggesting that ginger has high antibacterial activity (Suryanarayana *et al.,* 2010). These check Coliforms, *Staphylococcus* and *Salmonella*

In general phytogenic feed additives (herbs and their products) have a strong antibacterial and antifungal properties. They inhibit *E. coli. Proteus spp., Staphylococcus, Streptococcus* and *Salmonella.*

II. CONCLUSION

The primary mode of action of phytogenic feed additives is by beneficially affecting the ecosystem of GI tract through controlling the pathogens. This is benefitted to the animal during stress conditions by not losing the

immunity which otherwise usually occurs. There seems no restriction globally over the use of these phytogenic feed additives with a notion that some resistance will develop for them in the animal body

Even though a product is said to be of natural origin, it is not necessarily better or safer than antibiotics or other synthetic feed additives. It is important to note that various antibiotics also are of natural origin. The fact that some herbs and spices also exhibit antimicrobial properties suggests that phytogenic feed additives may pose similar risks to producers and meat consumers. Similarly, potential overdose that may be harmful to the pig also is possible. All of these considerations warrant further investigation into the safety of phytogenic feed additives both for humans and animals.

PFA should not only look to the profitability and superior quality of livestock products but also should look to food safety and environmental regulation. PFA was said to have reduce the environmental pollution by reducing the release of ammonia, methane and greenhouse gas emission. PFA include essential oils, spices, herbs and then products which improves growth rate, nutrient digestibility and gut health in animals. They can act as an alternate to AGP and the rapid growth of the popularity of organic farming can also considered as the major cause for exploring PFA. In a nut shell, PFA increases feed intake, improves gut function, reduces anti-oxidation of the cell and eliminates pathogens from the gut.

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