International Journal of Environment, Agriculture and Biotechnology
Vol-10, Issue-4; Jul-Aug, 2025
Peer-Reviewed International Journal
Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

A Review on the Use of Water Chestnut Flour in the Enrichment of Bakery Products

Prarthana Mitra, Zoha Mohammadi, Anusha MB

Department of Food Technology, Ramaiah University of Applied Sciences, Karnataka, India
Email id: anusha.ft.ls@msruas.ac.in

Received: 25 May 2025; Received in revised form: 23 Jun 2025; Accepted: 26 Jun 2025; Available online: 04 Jul 2025

Abstract— *Water chestnut (Trapa natans), known as Singhara in India, is an aquatic vegetable with significant nutritional and therapeutic properties. This review highlights its potential as a functional ingredient in food products, particularly through its derivative, water chestnut flour (WCF). Rich in essential nutrients, including dietary fibre, vitamins, and polyphenols, WCF has demonstrated numerous health benefits such as anti-inflammatory, anti-diabetic, and neuroprotective effects. Its gluten-free nature makes it particularly valuable in catering to the growing demand for nutritious, gluten-free foods. WCF has shown promise in bakery applications, improving the nutritional profile and sensory qualities of products like buns, bread, cakes, and biscuits. Additionally, it contributes to enhanced shelf life and texture due to its moisture-retaining properties. Studies reveal that WCF's incorporation into gluten-free formulations enhances dietary fibre, protein content, and sensory appeal while maintaining affordability and accessibility. By leveraging the nutritional and functional properties of water chestnuts, this review underscores their potential in addressing global dietary needs, supporting health-conscious consumers, and fostering sustainable food innovation.*

Keywords— ***Gluten-Free Products, nutritional enrichment, sensory characteristics, water chestnut (Trapa natans), water chestnut Flour (WCF).***

I. INTRODUCTION

Water chestnut, known as Singhara in India, is an annual aquatic plant with floating leaves, typically found in freshwater wetlands, ponds, lakes, and slow-moving sections of rivers.(Rajkumar & Rajithasri, 2022). The water chestnut, despite its name, is not a nut but an aquatic vegetable, that's grows submerged in the mud. Known scientifically as *Trapa natans* and belonging to the Lythraceae family, it is commonly called the Singhara in India (Rajput & Singh, 2023). Its fine roots anchor it in the mud, while a network of branching roots connects the stems to the water's surface. The plant has triangular, saw-toothed floating leaves that provide buoyancy, along with feather-like leaves along the submerged stem. Its white, four-petaled flowers bloom in June and are insect-pollinated. The fruit is a nut with four barbed spines and is a superfood (Mikulyuk & Nault, 2008). Water chestnut cultivation in India thrives in Madhya Pradesh, Uttar Pradesh, Bihar, and Odisha. The fruit, distinguished by its thorny and thornless varieties, flourishes uniquely in each region. Bihar is renowned for its red thorny variety, while both types grace the fertile lands of Madhya Pradesh and Uttar Pradesh(Rajkumar & Rajithasri, 2022). Available data reveals that the water chestnut is a rich source of essential minerals, proteins, lipids, and carbohydrates. It is also abundant in a range of vitamins, including B1, B2, B5, B6, E, A, and C. Additionally, the water chestnut provides dietary fibres, polyphenols such as phenolic acids and flavonoids, as well as hydrolysable tannins, contributing to its remarkable nutritional profile. This remarkable fruit boasts a diverse array of health-promoting properties, offering benefits such as anti-inflammatory, anti-diabetic, anti-microbial, and immunomodulatory effects. It also demonstrates neuroprotective qualities, along with potent anti-ulcer activity, among many other therapeutic virtues.(Rajput & Singh, 2023).

Despite their potential, these fruits are not widely recognized and are typically sold at low prices in local

markets, largely due to limited awareness of their nutritional benefits and insufficient research on their full potential (Raghav, 2024). Since water chestnut is rich in a wide variety of essential nutrients, it can be utilized to enhance the nutritional quality of baked products prepared in bakery units. This can help overcome the current lack of recognition and research, as enriching foods with such nutrients can boost their appeal and value in the market. The application of date fruit (Phoenix dactylifera L.) in creating innovative snack bars by replacing honey with date paste. Dates contributed to sweetness, texture enhancement, and nutritional density, offering a significant source of fibre, vitamins, and minerals while maintaining microbiological stability during storage. The findings suggest that incorporating date paste in snack bars can provide a healthier, functional food alternative that aligns with consumer demand for nutritious snacks. (Ibrahim et al., 2021)

Research into the functional, nutritional, and sensory qualities of food continues to grow, fuelled by the rising demand for healthy, balanced lifestyles and increased awareness. In the food industry, numerous studies have focused on the development of cereal-based functional foods. This review explores the use and potential applications of chestnut flour, a product with limited production in the bakery units(Mete & Altıner, 2017).

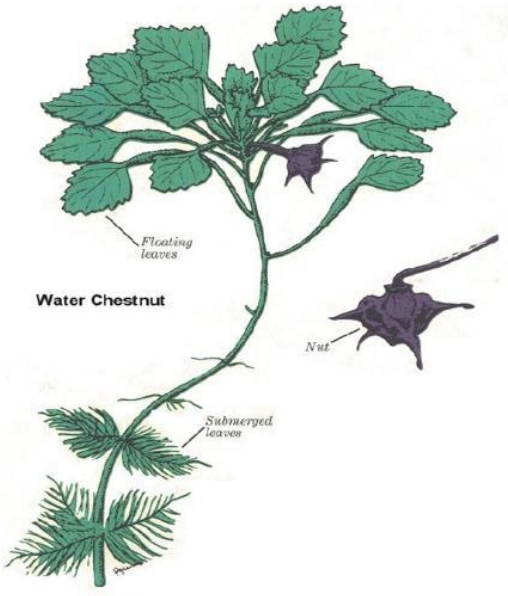

Fig 1: Water Chestnut Plant
(Rajkumar & Rajithasri,2022)

Fig 2 (a) water chestnut (b) water chestnut kernels (c) water chestnut flour (Hussain, Beigh, Naseer, et al., 2019)

Table 1: Taxonomic Classification of Singhara/ Water Chestnut:

Kingdom	**Plantae**
Phylum	**Tracheophyta**
Class	**Magnoliopsida**
Order	**Myrtales**
Family	**Lythraceae**
Genus	**Trapa**
Species	**Trapa natans**

(Palm et al., 2024)

Table 2: Comparative study of the chemical properties of water chestnut fruit and flour per 100g.

Constituent	Flour	Dried	Fresh
Moisture	11.4	10.1	52.9
Protein	6.1	6.0	3.2
Ash	2.35 ± 0.32	-	1.33 ± 0.04
Fat	3.7	3.4	1.84
Total Sugars	23.6	16.1	9.6
Calories	343	287	160
Fibre	14.2	13.8	7.3
Insoluble	13.2	12.7	6.7
Soluble	1.0	1.1	0.6
Starch	40	41.7	24.4

(Mete & Altıner, 2017; G. D. Singh et al., n.d.)

II. CHESTNUT FLOUR PRODUCTION

Chestnut flour, a naturally gluten-free product free from additives, is prepared through gentle methods like freeze-drying or scalding. The process begins with cleaning and sorting the chestnuts by size, followed by immersion in water for a day to ease peeling. After the softened chestnuts are separated from their shells using steam pressure, they are ground into flour. To preserve their nutritional value, the

chestnuts are dried at low temperatures, then cooled to room temperature. The flour is sifted and carefully packaged, with storage maintained under optimal conditions (+4°C)(Mete & Altıner, 2017).

Chestnut flour, being gluten-free and highly nutritious, is an excellent option for individuals with celiac disease. Research has shown that it can serve as a substitute for cow's milk in desserts and soups, making it suitable for children who may be allergic to lactose. This versatile flour can also be used in the preparation of milky puddings, bread, baby formulas, pasta, and flakes (e.g., cornflakes). Rich in protein, sugars (20-32%), starch (50-60%), dietary fibre (4-10%), and essential amino acids (47%), it contains low fat (2-4%) and is abundant in vitamins B, C, and E, as well as potassium, magnesium, and phosphorus. (Anonymous, 2016)(Mete & Altıner, 2017)

Fig 3: Steps for Chestnut Flour Production (Mete & Altıner, 2017).

Chestnut flour is increasingly utilized in a wide range of products, including cakes, cookies, pasta, milky puddings, bread, breakfast cereals, soups, sauces, and gravies. Given its potential to enhance both nutritional quality and health benefits, interest in chestnut flour is rapidly growing (Rajput & Singh, 2023).Studies predict that incorporating chestnut flour into various foods, especially baked goods, will foster the growth of diverse product markets by improving their nutritional value and functional properties. Additionally, chestnut flour is gaining recognition as an alternative flour additive (Mete & Altıner, 2017).Its rising popularity in the food industry is attributed to its exceptional nutritional and sensory qualities. The use of chestnut flour is regarded as advantageous at this stage, as it helps to address the common deficiencies of vitamin B, iron, and fibre typically found in many gluten-free products. Because of its nutritional value, chestnut flour is also used in gluten-free bread preparation(Shafi et al., 2017).

2.1 Enrichment of buns with water chestnut flour:

The demand for buns made with healthy flour options, such as water chestnut flour, has been steadily increasing. These alternative flours offer enhanced nutritional benefits, including higher fibre content, a lower glycaemic index, and an improved protein profile, aligning with the growing consumer preference for healthier food choices. The rise in dietary restrictions like gluten intolerance and diabetes has further fuelled the demand for gluten-free and low-sugar buns.

Water chestnut flour is rich in starch, dietary fibre, and essential minerals like potassium. It is gluten-free, promoting digestive health and potentially aiding weight management. Its low glycaemic index helps regulate blood sugar levels, making it suitable for diabetics. An investigation was carried out to develop buns incorporating varying levels of wheat flour, water chestnut flour, and soya flour. The quality was assessed based on parameters such as protein, fat, carbohydrates, ash, moisture, and total solids. Four treatments were tested; each replicated five times. The control (T0) consisted of 100% wheat flour. T1 was prepared with 85% wheat flour, 10% water chestnut flour, and 5% soya flour; T2 contained 80% wheat flour, 10% water chestnut flour, and 10% soya flour; and T3 included c75% wheat flour, 10% water chestnut flour, and 15% soya flour. T2 emerged as the best formulation, with average values of 10.51% protein, 8.14% fat, 56.55% carbohydrate, 22.24% moisture, 2.57% ash, and 77.76% total solids. A study revealed incorporating water chestnut flour into buns results in a firmer texture without compromising flavour or consumer acceptability. It also enhances shelf life due to its moisture-retaining properties. When combined with soya flour, it improves the buns' protein content and amino acid profile, further enhancing their nutritional value and texture. (H. Singh, Thakur, Wilson, et al., 2017).

2.2 Enrichment of breads with water chestnut flour:

A study examined the potential of water chestnut flour as an alternative ingredient in gluten-free bread formulations. The addition of water chestnut flour improved the bread's texture, contributing to a softer, more elastic crumb. This helped address the common challenge of density and crumbliness in gluten-free bread. This study investigated gluten-free bread formulations using chestnut and rice flours in various ratios (0/100, 10/90, 20/80, 30/70, 40/60, 50/50, 100/0). The effects of a hydrocolloid blend (xanthan-locust bean gum or xanthan-guar gum) and emulsifier

DATEM on dough rheology and bread quality were also examined for ratios of 10/90, 20/80, 30/70, and 40/60. Breads with a 30/70 chestnut/rice flour ratio, containing the xanthan–guar blend and emulsifier, exhibited superior quality, including improved hardness, specific volume, colour, and sensory characteristics. Its gluten-free nature and high fibre content make it a valuable ingredient for enhancing the quality of gluten-free bread, catering to the needs of health-conscious consumer(Demirkesen et al., 2010).

Another study indicated water chestnut flour contributed to an increase in bread volume, which is often a challenge in gluten-free formulations due to the absence of gluten. The supplementation of water chestnut flour altered the volatile profile of the bread, contributing to unique flavour characteristics. This could enhance the overall sensory quality of gluten-free bread without compromising its taste. This study evaluated contents (wheat/chestnut flour ratios: (A)100/0, (B)80/20, (C) 50/50 based on physico-chemical properties such as proximate composition, fatty acids, texture, colour, crumb grain, antioxidant capacity, and volatile profile. Antioxidant capacity increased with higher chestnut flour content, and a richer volatile profile, including toasty and nutty furans and woody and smoky phenolic compounds, was observed. Breads with an 80/20 ratio had a more heterogeneous crumb structure, with larger, asymmetrical cavities, while the 50/50 ratio resulted in lower volume, harder, and darker crumbs due to higher fibre and sugar content.(Dall'Asta et al., 2013).

Additionally, study was performed where bread was formulated with varying proportions of wheat flour and water chestnut flour (T1, T2, and T3), with the respective flour ratios of 9.7:0.3, 9.4:0.6, and 9.1:0.9. The formulation with 3% water chestnut flour (T1) exhibited higher acceptability compared to the other treatments. Furthermore, the hardness values for T1 were lower than those for T2 and T3. focussing on the textural and sensory properties of bread supplemented with water chestnut flour stated that the flour contributes a mild, nutty flavour, boosting the sensory appeal of the bread(Bhat et al., 2015)

2.3 Enrichment of muffins with water chestnut flour:

The growing demand for muffins is driven by their convenience, versatility, and popularity as a snack or breakfast item. The flour used in muffin preparation is crucial because it impacts both the nutritional profile and the glycaemic index (GI) of the product. A recent study found that water chestnut flour helps create low-glycaemic muffins, making them suitable for people with diabetes or those managing blood sugar. It enhances the muffins' nutritional value by adding fibre, protein, and minerals, promoting digestive health. The flour also improves texture, making the muffins softer and moister. Combined with barley flour, it provides a healthier, more functional option for health-conscious consumers. Overall, water chestnut flour is a key ingredient for making nutritious, low-GI muffins with better texture and health benefits. In the study, the resistant starch content of the final muffin product (43.5%) was higher than that of water chestnut flour (WCF) at 40.24% and barley flour (BF) at 5.18%. The research concluded that replacing 30% of WCF with BF is feasible for creating low glycaemic index (GI) muffins with good sensory qualities. During storage, muffins made with 70% WCF and 30% BF showed increased firmness, water activity, free fatty acid levels, and peroxide value, while moisture content and overall acceptability declined. (Hussain et al., 2019).

Another study on muffins with chestnut flour substitution assessed sensory attributes like texture, taste, and overall acceptability. Five treatments were conducted, varying the water chestnut flour content: Control (0g), T1 (4g), T2 (6g), T3 (8g), T4 (10g), and T5 (12g). The highest mean value for appearance was recorded in T4 (7.00 ± 0.82), while the highest flavour and aroma scores were observed in T5 (7.5 ± 2.34). For colour, the highest score was also recorded in T4 (7.00 ± 0.82). The highest texture score was noted in both T4 and T3 (7.25 ± 3.10). Softness was highest in T5, and mouthfeel was highest in T4 (6.50 ± 1.43). Finally, the highest aftertaste score was recorded in T4 (7.00 ± 0.82). Results showed that chestnut flour improved flavour and texture compared to traditional flour, with higher scores for taste and texture in muffins with increased chestnut flour content. The control muffins had lower scores, indicating the positive impact of chestnut flour on sensory characteristics(Nazir, 2022).

2.4 Enrichment of biscuits with water chestnut flour:

The enrichment of gluten-free biscuits with water chestnut flour (C1000) significantly influenced their hydration properties, physical characteristics, and oxidative stability. Water chestnut flour exhibited higher water-binding capacity (WBC) and water absorption index (WAI) compared to other gluten-free flours, attributed to its high fibre, protein content, and damaged starch. A 50:50 blend of chestnut flour and gluten-free mix (M500C500) showed optimal hydration properties, enhancing dough machinability and biscuit texture. However, excessive use (1000 g/kg) led to over-caramelization and diminished quality, highlighting 500 g/kg as the ideal level for achieving improved dough characteristics, texture, and oxidative stability.

Incorporating chestnut flour into biscuit formulations also impacted their texture, colour, and shelf life. Biscuits with higher chestnut flour content became firmer and darker due

to its antioxidant properties and fibre content, which improved oxidative stability and appearance. Over 60 days of storage, all formulations showed increased hardness, with the 500 g/kg blend providing the best balance of quality and stability. The study emphasizes the potential of chestnut flour as a functional ingredient for gluten-free baked goods, warranting further exploration of optimal formulations and storage conditions within the 500–800 g/kg range (Paciulli et al., 2018)

The potential of substituting refined wheat flour with nut and legume powders, including water chestnut and barley flour, is to create low glycaemic index crackers. These substitutions aimed to improve postprandial glycaemic responses, a critical factor in managing diabetes and related complications. Crackers partially made with water chestnut flour demonstrated a low glycaemic index, enhancing blood glucose regulation compared to wheat-based crackers. Such findings highlight water chestnut flour's potential as a functional, gluten-free ingredient that offers nutritional benefits and supports better glycaemic control, making it a valuable addition to health-focused baked products (Wongdokmai et al.,2024).

2.5 Enrichment of cakes with water chestnut flour:

Water chestnut flour (WCF) has emerged as a promising gluten-free alternative for bakery products, offering significant potential for cakes and pastries. Studies have explored its application with hydrocolloids like sodium alginate, guar gum, and carboxymethyl cellulose (CMC) using two WCF varieties (Kashmir and Punjab). Sodium alginate enhanced moisture retention and volume, while guar gum improved firmness and cohesiveness, with Punjab WCF and guar gum yielding the best sensory results. Nutritional analysis revealed higher moisture and ash content but lower protein in WCF cakes compared to traditional options, alongside calorie and fat variations, making it ideal for health-conscious consumers and those with celiac disease (Mir et al.,2014).

Modified water chestnut starch (WCS) has also shown potential to enhance the texture and sensory qualities of sponge cakes. Variants like acetylated, acid-thinned, and pregelatinized starch improved volume and uniformity indices, with double-modified starches providing superior sensory properties. These innovations highlight WCS as an effective means to enhance cake quality and appeal (Zubala Lutfi & Abid Hasnain,2009).

Furthermore, incorporating 9% WCF into traditional Portuguese pastries like "económicos" improved their nutritional value by introducing polysaccharides, fibre, essential amino acids, and vitamins while reducing fat and calorie content. The minimal impact on texture and appearance ensured consumer acceptance, and the use of non-marketable chestnuts emphasized sustainability. Collectively, these findings underscore WCF's potential to revolutionize gluten-free bakery products while maintaining quality, affordability, and health benefits (Fernandes et al,.2022).

2.6 Enrichment of cookies with water chestnut flour:

The study investigated the functional and sensory properties of cookies prepared by substituting wheat flour with a blend of water chestnut flour (WCF) and cassava flour (CF) at varying proportions. The results revealed that cookies with higher WCF and CF proportions exhibited increased spread ratios, softer textures, and darker colours compared to those made with wheat flour. These cookies also showed lower moisture, fat, and protein content, with an enhanced carbohydrate and fibre profile, aligning with the nutritional demands of gluten-free diets. Among the formulations, cookies made with a 50:50 blend of WCF and CF achieved the highest sensory ratings, showcasing their appeal for health-conscious consumers and those with celiac disease. The findings highlight the potential of water chestnut and cassava flours as cost-effective, gluten-free alternatives in bakery applications. The study emphasizes their ability to enhance the nutritional value and acceptability of bakery products, providing a sustainable solution to meet the growing demand for gluten-free options while supporting the use of underutilized crops like water chestnuts (Bala et al.,2015).

Water chestnut flour (WCF) outperformed refined wheat flour in phenolic, flavonoid, mineral content, and antioxidant properties, despite having a greater retrogradation tendency and lower peak viscosity. WCF-wheat flour blends and cookies exhibited decreased water activity with higher WCF content, while baking enhanced the antioxidant capacity, particularly in WCF cookies, which showed better retention of phenolic and flavonoid content compared to wheat cookies. Sensory analysis indicated fair acceptability for 100% WCF cookies, highlighting WCF as a gluten-free, antioxidant-rich alternative for cookie production (Shafi et al.,2016).

2.7 Enrichment of crackers with water chestnut flour:

The study explored the development of low glycaemic index (GI) crackers using a blend of water chestnut flour (WCF) and barley flour (BF) in various ratios. Among the formulations, a 70:30 WCF:BF blend yielded crackers with desirable sensory and physical attributes, including increased protein, fibre, and mineral content compared to WCF alone. These crackers also demonstrated a significantly lower glycaemic load, making them suitable for diabetic and health-conscious consumers. The resistant starch content was higher, contributing to improved dietary

benefits, while the blend maintained an appealing taste and texture (Hussain et al.,2019).

Storage studies confirmed the stability of the developed crackers, which maintained safety and quality for up to 35 days in metallized polyethylene under ambient and refrigerated conditions. The research highlights the potential of underutilized crops like water chestnut and barley in creating innovative, health-promoting bakery products, thereby offering sustainable and nutritious options for consumers while supporting agricultural value addition (Hussain et al.,2019).

III. CONCLUSION

Water chestnut flour (WCF) represents a transformative ingredient in modern food production, particularly for gluten-free and health-promoting products. This review consolidates evidence of its versatile applications, from enhancing the nutritional content of baked goods to supporting dietary restrictions for individuals with gluten intolerance and diabetes. WCF's inherent properties—rich in fiber, starch, and essential micronutrients—address the nutritional deficiencies often found in gluten-free diets. Its potential to improve sensory and structural attributes, such as texture, volume, and shelf life, has been validated across a spectrum of products, including bread, biscuits, cakes, and crackers. Additionally, its low glycaemic index and bioactive compounds provide significant therapeutic benefits, catering to health-conscious consumers.

The sustainable cultivation and processing of water chestnuts offer economic and ecological advantages, particularly for regions where they are abundant but underutilized. Despite these benefits, limited consumer awareness and research gaps hinder WCF's widespread adoption. Future research should focus on optimizing its applications in diverse food matrices, investigating its interactions with other ingredients, and conducting comprehensive sensory evaluations. By addressing these challenges, WCF can solidify its role as a cornerstone in the development of nutritious, affordable, and sustainable food products, meeting the growing demand for functional foods and fostering innovation in the global food industry.

ACKNOWLEDGEMENT

The authors are grateful to the Department of Food Technology, Ramaiah University of Applied Sciences, Bengaluru, Karnataka, India.

REFERENCES

[1] Alfasane, M. A., Khondker, M., & Rahman, M. M. (2011). Biochemical composition of the fruits of water chestnut (Trapa bispinosa Roxb.). *Dhaka University Journal of Biological Sciences*, *20*(1), 95–98.

[2] Aleem, S., Butt, A. Y., Masood, R., & Ashraf, H. Development Of Flat Bread by Utilizing Moringa Leaves Powder and Water Chestnut Powder to Combat Malnutrition.

[3] Bascuñán, K. A., Vespa, M. C., & Araya, M. (2017). Celiac disease: Understanding the gluten-free diet. *European Journal of Nutrition*, *56*(2), 449–459. https://doi.org/10.1007/s00394-016-1238-5

[4] Bhat, J., Afzal, S., Gull, A., Haq, R., & Safapuri, T. A. (n.d.). *Textural and Sensory Characteristics of Bread Made from Wheat Flour Supplemented with Water Chestnut*.

[5] Dall'Asta, C., Cirlini, M., Morini, E., Rinaldi, M., Ganino, T., & Chiavaro, E. (2013). Effect of chestnut flour supplementation on physico-chemical properties and volatiles in bread making. *LWT - Food Science and Technology*, *53*(1), 233–239. https://doi.org/10.1016/j.lwt.2013.02.025

[6] Delgado, T., Pereira, J. A., Casal, S., & Ramalhosa, E. (2016). Effect of Drying on Color, Proximate Composition and Drying Kinetics of Sliced Chestnuts. *Journal of Food Process Engineering*, *39*(5), 512–520. https://doi.org/10.1111/jfpe.12244

[7] Demirkesen, I., Mert, B., Sumnu, G., & Sahin, S. (2010). Utilization of chestnut flour in gluten-free bread formulations. *Journal of Food Engineering*, *101*(3), 329–336. https://doi.org/10.1016/j.jfoodeng.2010.07.017

[8] Di Cairano, M., Condelli, N., Caruso, M. C., Marti, A., Cela, N., & Galgano, F. (2020). Functional properties and predicted glycemic index of gluten free cereal, pseudocereal and legume flours. *LWT*, *133*, 109860. https://doi.org/10.1016/j.lwt.2020.109860

[9] El Khoury, D., Balfour-Ducharme, S., & Joye, I. J. (2018). A Review on the Gluten-Free Diet: Technological and Nutritional Challenges. *Nutrients*, *10*(10), 1410. https://doi.org/10.3390/nu10101410

[10] Ghosh, T., & Ghosh, J. (n.d.). *3. A Study on the Antibacterial Activities and Medical Properties of Water Chestnut*.

[11] Hoque, A., Davey, M. R., & Arima, S. (2009). Water Chestnut: Potential of Biotechnology for Crop Improvement. *Journal of New Seeds*, *10*(3), 180–195. https://doi.org/10.1080/15228860903094069

[12] Kourkouta, L., Koukourikos, K., Iliadis, C., Ouzounakis, P., Monios, A., Tsaloglidou, & A. (2017). Bread and Health. *Journal of Pharmacy and Pharmacology*, *5*(11). https://doi.org/10.17265/2328-2150/2017.11.005

[13] Lutfi, Z., Nawab, A., Alam, F., & Hasnain, A. (2017). Morphological, physicochemical, and pasting properties of modified water chestnut (*Trapabispinosa*) starch. *International Journal of Food Properties*, *20*(5), 1016–1028. https://doi.org/10.1080/10942912.2016.1193514

[14] Mete, M., & Altıner, D. D. (2017). Chestnut flour and applications of utilization. *International Journal of Food Engineering Research*, *3*(1), 9–16.

[15] Mikulyuk, A., & Nault, M. (2008). *Trapa natans (waterchestnut)* (p. 55040) [Dataset]. https://doi.org/10.1079/cabicompendium.55040

[16] Mondal, A., & Datta, A. K. (2008). Bread baking – A review. *Journal of Food Engineering*, *86*(4), 465–474. https://doi.org/10.1016/j.jfoodeng.2007.11.014

[17] Nadeem, M., Rehman, A., Munir, M., Fatima, H., Malik, F., Iqbal, A., & Asif, A. (2022). Impact of Water Chestnut Addition on Development and Characterization of Supplemented Date Bar. *Pakistan Journal of Agricultural Research*, *35*(4). https://doi.org/10.17582/journal.pjar/2022/35.4.597.604

[18] Ngemakwe, P. N., Le Roes-Hill, M., & Jideani, V. (2015). Advances in gluten-free bread technology. *Food Science and Technology International*, *21*(4), 256–276. https://doi.org/10.1177/1082013214531425

[19] Raghav, P. K. (n.d.). *Formulation and sensory evaluation of water chestnut flour laddoo*.

[20] Rajkumar, P., & Rajithasri, M. (n.d.). *Water chestnut: Growing conditions, nutritional and phytochemical composition, novel extraction methods and health properties*.

[21] Rajput, J. D., & Singh, S. P. (2023). Water Chestnut (Trapa natans L.): Functional characteristics, nutritional properties and applications in food industry: A review. *The Journal of Phytopharmacology*, *12*(2), 119–126.

[22] Razvy, M. A., Faruk, M. O., & Hoque, M. A. (n.d.). *Environment friendly antibacterial activity of water chestnut fruits*.

[23] Rehman, A. U., Khan, A. U., Sohaib, M., & Rehman, H. (2024). Comparative Analysis of Nutritional Properties, Phytochemical Profile, and Antioxidant Activities between Red and Green Water Chestnut (Trapa natans) Fruits. *Foods*, *13*(12), 1883. https://doi.org/10.3390/foods13121883

[24] Singh, G. D., Siingh, S., Jindal, N., Bawa, A. S., & Saxena, D. C. (n.d.). *Physico-chemical characteristics and sensory quality of Singhara (Trapa natans L.): An Indian water chestnut under commercial and industrial storage conditions*.

[25] Singh, H., Thakur, S., Kishor, K., & Rai, B. S. (n.d.). *Studies on cost of production for value added nutritional bun with different levels of wheat flour, soy flour, water chestnut flour*.

[26] Singh, H., Thakur, S., Wilson, I., Kishor, K., & Rai, S. (n.d.). *Studies on quality parameters of bun incorporated with wheat flour water chestnut flour and soya flour*.

[27] Šmídová, Z., & Rysová, J. (2022). Gluten-Free Bread and Bakery Products Technology. *Foods*, *11*(3), 480. https://doi.org/10.3390/foods11030480

[28] Stampfli, L., & Nersten, B. (1995). Emulsifiers in bread making. *Food Chemistry*, *52*(4), 353–360. https://doi.org/10.1016/0308-8146(95)93281-U

[29] Vici, G., Belli, L., Biondi, M., & Polzonetti, V. (2016). Gluten free diet and nutrient deficiencies: A review. *Clinical Nutrition*, *35*(6), 1236–1241. https://doi.org/10.1016/j.clnu.2016.05.002

[30] You, Y., Duan, X., Wei, X., Su, X., Zhao, M., Sun, J., Ruenroengklin, N., & Jiang, Y. (2007). Identificationof Major Phenolic Compounds of Chinese Water Chestnut and their Antioxidant Activity. *Molecules*, *12*(4), 842–852. https://doi.org/10.3390/12040842

[31] Hussain, S. Z., Beigh, M. A., Qadri, T., Naseer, B., & Zargar, I. (2019). Development of low glycemic index muffins using water chestnut and barley flour. *Journal of Food Processing and Preservation*, *43*(8). https://doi.org/10.1111/jfpp.14049

[32] Paciulli, M., Rinaldi, M., Cavazza, A., Ganino, T., Rodolfi, M., Chiancone, B., & Chiavaro, E. (2018). Effect of chestnut flour supplementation on physico-chemical properties and oxidative stability of gluten-free biscuits during storage. *Lwt*, *98*, 451-457. https://doi.org/10.1016/j.lwt.2018.09.002

[33] Fernandes, F. A., Pedrosa, M. C., Ueda, J. M., Ferreira, E., Rodrigues, P., Heleno, S. A., ... & Barros, L. (2022). Improving the physicochemical properties of a traditional Portuguese cake–"económicos" with chestnut flour. *Food & function*, *13*(15), 8243-8253. https://pubs.rsc.org/en/content/articlelanding/2022/fo/d2fo01385a/unauth#!divRelatedContent&articles

[34] Lutfi, Z., & Hasnain, A. (2009). Effect of Modified Water Chestnut (Trapa bispinosa) Starch on Physical and Sensory Properties of Sponge Cakes: Effect of Water Chestnut Starch on Cakes. *Biological Sciences-PJSIR*, *52*(3), 146-150. http://www.v2.pjsir.org/index.php/biological-sciences/article/view/538

[35] Mir, N. A., Gul, K., & Riar, C. S. (2015). Technofunctional and nutritional characterization of gluten-free cakes prepared from water chestnut flours and hydrocolloids. *Journal of Food Processing and Preservation*, *39*(6), 978-984. https://doi.org/10.1111/jfpp.12311

[36] DESAI, M. P., & BODHANKAR, H. Formulation of Gluten Free Baked Cookies with Fibre Prepared Using a Range of Trapa natans (Water Chestnut) Flour Fortified with Prunus dulcis (Almond) Flour. http://scientificresearchjournal.com/wp-content/uploads/2023/03/Home-Science-Vol-10_A-39-44-Full-Paper.pdf

[37] Beigh, M. A. (2019). *Evaluation and optimization of water chestnut processing techniques for development of value added products* (Doctoral dissertation, SKUAST Kashmir). https://krishikosh.egranth.ac.in/items/2b3b9d09-d26e-412a-8d24-c12b2fdd98b3

[38] Shafi, M., Baba, W. N., & Masoodi, F. A. (2017). Composite flour blends: Influence of particle size of water chestnut flour on nutraceutical potential and quality of Indian flat breads. *Journal of Food Measurement and Characterization*, *11*, 1094-1105. https://doi.org/10.1007/s11694-017-9486-5

[39] Kakkar, S., Tandon, R., & Tandon, N. (2023, September). Analysing the nutraceutical and medicinal values of water chestnut and its waste in functional foods: A review. In *AIP Conference Proceedings* (Vol. 2800, No. 1). AIP Publishing. https://doi.org/10.1063/5.0170418

[40] Alam, H. M., Nadeem, R., Rubab, G., Bilal, H., Arooj, H., Ashraf, I., ... & Tariq, R. (2021). Nutraceutical Properties of Water Chestnut: Nutraceutical Properties of Water Chestnut. *DIET FACTOR (Journal of Nutritional and Food Sciences)*, 03-08. https://doi.org/10.54393/df.v2i2.34

[41] Tang, X. T., Zheng, F. S., Qin, J., Lu, M. X., & Du, Y. Z. (2016). Genetic structure of water chestnut beetle: Providing evidence for origin of water chestnut. *PLoS One*, *11*(7), e0159557. https://doi.org/10.1371/journal.pone.0159557

[42] Tulyathan, V., Boondee, K., & Mahawanich, T. (2005). Characteristics of starch from water chestnut (Trapa bispinosa Roxb.). *Journal of Food Biochemistry*, *29*(4), 337-348. https://doi.org/10.1111/j.1745-4514.2005.00010.x

[43] Devi, N. M., Prasad, R. V., & Sagarika, N. (2018). A review on health benefits and nutritional composition of pumpkin seeds. *International journal of chemical studies*, *6*(3), 1154-1157.

[44] Chochkov, R., Zlateva, D., Stefanova, D., & Ivanova, P. (2024). Effect of pumpkin seed flour, chestnut flour, and rosehip flour on wheat bread staling rate. *Ukrainian Food Journal*, 76.

[45] Silav-Tuzlu, G., & Tacer-Caba, Z. (2021). Influence of chia seed, buckwheat and chestnut flour addition on the overall quality and shelf life of the gluten-free biscuits. *Food Technology and Biotechnology*, *59*(4), 463-474. https://doi.org/10.17113/ftb.59.04.21.7204

[46] Weber, C. W., Gentry, H. S., Kohlhepp, E. A., & McCrohan, P. R. (1991). The nutritional and chemical evaluation of chia seeds. *Ecology of Food and Nutrition*, *26*(2), 119-125. https://doi.org/10.1080/03670244.1991.9991195

[47] Li, R., Sharma, A. K., Zhu, J., Zheng, B., Xiao, G., & Chen, L. (2022). Nutritional biology of chestnuts: A perspective review. *Food Chemistry*, *395*, 133575. https://doi.org/10.1016/j.foodchem.2022.133575

[48] Demirkesen, I., Sumnu, G., & Şahin, S. (2011). Utilization of chestnut flour in gluten-free cakes. https://hdl.handle.net/11511/75964

[49] Mishra, A., Devi, M., & Jha, P. (2015). Development of gluten free biscuits utilizing fruits and starchy vegetable powders. *Journal of food science and technology*, *52*, 4423-4431. https://link.springer.com/article/10.1007/s13197-014-1521-5

[50] Rossukon, W., Pimnapanut, S., & Aree, P. (2024). Effects of nut and legume powder substitution in crackers prepared with wheat flour on postprandial plasma glucose response among healthy Thai adults. *Malaysian Journal of Nutrition*, *30*(2). https://doi.org/10.31246/mjn-2023-0056

[51] Rupam, P., & Jacob, T. Process optimization and quality evaluation of fasting cookies developed by incorporating water chestnut, sweet potato, Amaranth Grain Flour. *Energy (Kcal)*, *355*(344.28), 330. http://www.foodsciencejournal.com/

[52] Biswas, K. K., Faruk, M. O., Amin, M. Z., & Shaha, R. K. (2012). Antibacterial activity of two varieties of water chestnuts (Trapa sp.). *Journal of Biological Sciences*, *20*, 115-123. http://www.banglajol.info/index.php/JBS/index

[53] Nazir, A. (2022). Qualitative and sensory characterization of muffins synthesized with chestnut flour substitution. *Pure and Applied Biology*, *11*(3). https://doi.org/10.19045/bspab.2022.110077

[54] Baehaki, A., Widiastuti, I., Lestari, S., Masruro, M., & Putra, H. A. (2021). Antidiabetic and anticancer activity of Chinese water chestnut (Eleocharis dulcis) extract with multistage extraction. *Journal of Advanced Pharmaceutical Technology & Research*, *12*(1), 40-44. 10.4103/japtr.JAPTR_67_20

[55] Hodge, W. H. (1955). *The Chinese waterchestnut* (No. 956). US Department of Agriculture.

[56] Zhou, S., Reddy, C. K., Du, B., & Xu, B. (2021). Pasting, thermal, and functional properties of wheat flour and rice flour formulated with chestnut flour. *Bioactive Carbohydrates and Dietary Fibre*, *26*, 100290. https://doi.org/10.1016/j.bcdf.2021.100290

[57] Navarro, J., Vila, M. T., & Mamaril, G. (2016). Acceptability of Water Chestnut Flour in "Puto" Making. *Southeast Asian Journal of Science and Technology*, *1*(1), 40-42 https://sajst.org/online/index.php/sajst/article/view/8

[58] Adkar, P., Dongare, A., Ambavade, S., & Bhaskar, V. H. (2014). Trapa bispinosa Roxb.: a review on nutritional and pharmacological aspects. *Advances in Pharmacological and Pharmaceutical Sciences*, *2014*(1), 959830. https://doi.org/10.1155/2014/959830

[59] Ahmed, J., Al-Attar, H., & Arfat, Y. A. (2016). Effect of particle size on compositional, functional, pasting and rheological properties of commercial water chestnut flour. *Food Hydrocolloids*, *52*, 888-895. https://doi.org/10.1016/j.foodhyd.2015.08.028

[60] Agrahari, A. K., Khaliquzzama, M., & Panda, S. K. (2010). Evaluation of analgesic activity of methanolic extract of Trapa natans l. var. Bispinosa roxb. Roots. *Journal of Current Pharmaceutical Research*, *1*(1), 8-11.

[61] Panda, S. K., Kbaliquzzama, M., & Agrahari, A. K. (2010). EVALUATION OF PSYCHOPHARMACOLOGICAL ACTIVITY OF METHANOLIC EXTRACT OF TRAPA NATANS L. VAR. BISPINOSA ROXB. ROOTS. *Advances in Pharmacology and Toxicology*, *11*(2), 71.

[62] Rodrigues, R., Agarwal, P. C., & Saha, N. K. (1964). Canning of water chestnut (Singhara)(Trapa bispinosa Roxb). *Journal of Food Science and Technology*, *1*, 28-31. http://ir.cftri.res.in/id/eprint/3268