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A Review on Importance Nutritional Value and Uses of Water Chestnut (*Trapa natans* var. bispinosa Roxb.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Water chestnut (*Trapa natans* var. bispinosa Roxb.), an aquatic perennial plant. This research aims to elucidate the health benefits of water chestnut, focusing on its nutritional composition, medicinal properties, and potential roles in promoting overall wellness. Water chestnuts are a rich source of essential nutrients, including vitamins B6, C, and E, as well as minerals such as potassium, phosphorus, and magnesium. Antioxidants play a critical role in reducing inflammation, which is linked to numerous health issues, including heart disease and arthritis. The anti-inflammatory properties of water chestnuts may help alleviate symptoms associated with these conditions, improving overall quality of life. The potassium content helps regulate blood pressure, while dietary fiber aids in cholesterol management. These factors contribute to a healthier cardiovascular

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system, potentially reducing the risk of heart disease and stroke. Water chestnuts are also renowned for their hydrating properties, as they contain a highwater content, making them an excellent choice for maintaining hydration, especially in hot climates or during physical activities.

Keywords: Water chestnuts; nutritional value; uses; health benefit.

1. INTRODUCTION

Water chestnut (*Trapa natans* var. bispinosa Roxb.) is an important aquatic fruit crop in India, and it belongs to the 'Trapaceae' family. Water chestnut, also known as Singhara in Hindi, is said to have originated in India, China, and Eurasia. It is a free-floating annual aquatic plant that grows in shallow fields, ponds, and swampy areas. It prefers nutrient-rich water with a pH range of 6.7 to 8.2 (Anonymous, 2002; Bhatiwal et al*.,* 2012). Water chestnuts are widely grown in India, particularly in Madhya Pradesh, Uttar Pradesh, Bihar, Odisha, West Bengal, Jharkhand, Karnataka, and Jammu & Kashmir. The plant is commercially farmed in tropical places around the world, including Pakistan, Sri Lanka, Indonesia, and Africa. It's common in Indonesia, Southeast Asia, southern China, and the eutrophic waterways of Japan, Italy, and tropical America. It has also naturalized in several places of the Eastern United States, where it thrives in tropical and subtropical conditions (Takano and Kadono, 2005). Fresh water chestnuts have the highest water content (80%) (Puste, 2004), starch (52%), protein (1.87%), and total soluble solids (TSS) (7–8%) (Singh et al*.,* 2010). They are also high in fiber, vitamin B, calcium (Ca), potassium (K), iron (Fe), and zinc (Adkar et al*.* 2014) and (Alfasane et al*.* 2011), fresh chestnuts contain 4.40% protein and 22.3% carbohydrate, respectively. Water chestnuts are also a good source of crude fiber, with the green variety having 2.13% and the red type having 2.27% (Faruk et al*.,* 2012). Water chestnut flour contains a considerable amount of potassium and fiber. Each cup of water chestnut slices contains around 130 calories. In India, water chestnut flour is consumed during fasting days (Singh, 2017). Water chestnuts' protein and carbs include a significant quantity of flavonoid and antioxidants, making them potential sources of nutrition (Mann et al*.,* 2012). Water chestnuts have a strong antiulcer effect, considerably lowering ulcer indices in both pyloric and aspirin-induced ulceration instances (Kar et al*.,* 2010). Furthermore, both red and green water chestnuts have antibacterial properties (Razvy et al*.,* 2011). Quantitative determination of mineral (sodium, potassium, calcium, phosphorus, iron, manganese, copper, and zinc) and vitamin (vitamin C, vitamin B6, vitamin B2, vitamin B3, vitamin A, and *b*-Carotene) composition was also assessed. Based on the findings, the proximate compositions of WCN green and red varieties varied greatly as WCN green contained significantly higher protein (1.72%), fat (0.65%), dietary fiber (2.21%), moisture (70.23%), ash (1.16%), and energy content (112.8 Kcal) than WCN red. In WCN green, the macro–micromineral concentrations were significantly higher than WCN red. Among the minerals analyzed, potassium was the most abundant mineral found in both varieties (Rehman et al*.,* 2024).

2. BOTANICAL DESCRIPTION

A floating aquatic plant with two leaf types is called a water chestnut. One grows along the length of the stem, split like a feather and submerged. Undivided floating leaves that form a rosette close to the water's surface make up the other (Jana, 2016). The floating leaves are fan-shaped, serrated on the edges, and rhomboid. Water chestnut Inflorescence become Corymb. Their diameter ranges from 2 to 6.5 cm, with their width being more than their length (Zhu, 2016). According to (Chandana et al*.,* 2013), the undersides of the leaves are reddish-purple, while the uppers are dark green. The plant's spongy, buoyant, cord-like stems can grow up to 16 feet in length, though most of them are usually between 6 and 8 feet. According to (Adkar et al*.,* 2014), a channel of branching roots anchors the stems to the water's bed. White flowers have four petals that are around 8 mm long. It starts to bloom in August and is situated in the middle of the rosette (Singh et al*.,* 2018; Jana, 2016). The fruit features a bony or woody nut that is 2.5 to 5 cm in diameter and has two or four robust horns or spines. While the fruit of Trapa bicorn resembles that of *Trapa natans*, it bears two spines instead of four (Jana, 2016; Adkar et al*.,* 2014).

2.1 Habitat

Worldwide, under full sun and in freshwaters rich in nutrients but low in energy, *Trapa natans* can

be found (Hummel and Kiviat, 2004). It tends to avoid waters that are high in calcium (PFAF, 2000) and is typically found in waters with an alkalinity of 12 to 128 mg/L of calcium carbonate (O'Neill, 2006). The average depth of water that *Trapa natans* dwell has been reported in a variety of ways. According to some sources (Van Driesche, 2002), *T. natans* can grow in water as deep as five meters, according to other sources (Hummel and Kiviat, 2004), and yet other sources (PFAF, 2000) state that the maximum depth is 0.6 meters. The species is most common in water that is about two meters deep and on soft terrain, according to (Hummel and Kivat, 2004).

2.2 Flowering and Fruiting

Following the start of the rainy season, which is usually in July, the creepers begin their great time of growth, and by the end of July, flower bud initiation occurs. After being transplanted, the plant takes approximately one month to begin flowering. The plants don't stop blossoming once they get going, even as they become older and eventually die (Khanna, 1963). The process of flower opening and anther dehiscence practically happen at the same time, which guarantees self-pollination (Khanna, 1963). There are roughly 30 to 35 leaves on each stalk, and every leaf has a single bud that appears from its axil and grows over the course of four to six days. While fruit development occurs beneath the water's surface, flower opening and fertilization occur outside of it. It is possible for a bloom to turn into a fruit within 10 to 15 days of pollination (Chakor, 1974). But after 21 days of anthesis, (Purew and Kong, 1958) noted that the fruit was ready to be harvested. The observations show that the time between anthesis and fruit maturity varies, which could be caused by variations in the climate or in the varieties.

3. NUTRITIONAL VALUE OF WATER CHESTNUT

Trapa bispinosa fruits have a biochemical makeup that has been examined. The results indicate that the fruit is suitable for inclusion in a human diet and may include significant amounts of protein, carbohydrates, and minerals (Alfasane et al*.,* 2011). In terms of nutrients, water chestnuts have the following composition: 62.5 percent moisture, 1.04 percent ash, 2.13% crude fiber, 0.92% total soluble sugar, 0.33% reducing sugar, 0.59% nonreducing sugar, 8.7% starch, and 0.84% fat. Beta-carotene was 60 micrograms, vitamin C was 1.1 mg, water soluble protein was 0.275 mg, and total phenol was 0.5 mg in one hundred grams of green variety. Iron, copper, manganese, and zinc were found in 200, 430, 90, and 600 parts per milligram, respectively, while potassium was found in 5.22%, sodium in 0.64%, calcium in 0.25%, phosphorus in 6.77%, and sulphur in 0.38% of the green variety's mineral components. Moisture (62.7%), ash (1.30%), crude fiber (2.27%), total soluble sugar (0.90%), reducing sugar (0.30%), nonreducing sugar (0.60%), starch (8.2%), and fat (0.83%) were all present in the red variant. Within 100 grams, the red type had 0.251 mg of water-soluble protein, 92 microg of beta-carotene, 0.9 mg of vitamin C, and 0.60 mg of total phenol. Potassium (5.32%), sodium (0.59%), calcium (0.26%), phosphorus (6.77%), sulphur (0.32%), iron (200 ppm), copper (450 ppm), manganese (110 ppm), and zinc (650 ppm) were all present in the red variety. Both types frequently contained the free amino acids glutamic acid, tryptophan, tyrosine, alanine, lysine, and leucine. Furthermore, cysteine, arginine, and proline, as well as glutamine and asparagine, were present in the green and red variants, respectively. As a result, the current study clarifies the nutritional differences between the two types of water chestnuts and raises the possibility that they are essential for human nutrition (Faruk et al*.,* 2012).

4. MEDICINAL VALUE

Medicinal value of the whole herb and fruit have been recognized in folklore medicine as a cure for various diseases (Rani et al*,* 2016). The whole herb has been reported for hepato - protective activity, antimicrobial activity, antibacterial activity (Razvy et al*.,* 2011), antitumor activity, antioxidant activity and free radical scavenging activity (Chandana et al*.,* 2013; Das et al*.,* 2011; Jha, 1999 & Jana et al*.,* 2020). The fruits have been used as an anti - inflammatory, anti - diarrhea, intestinal astringent, aphrodisiac antileprotic agent and in urinary discharges, fractures, bronchitis, and anemia (Kirtikar et al., 2006). The fruits of *T. bispinosa*. have been identified as the Ayurvedic drug Shurangataka. It is also said to have cancer - preventing properties. Stem juice is used in ophthalmic preparations.

4.1 Reduce the Risk of Heart Disease

With modernization, the risk of chronic diseases such as heart disease has increased, making it one of the leading causes of death worldwide. Heart disorders are caused by a variety of

causes, including excessive blood pressure, high blood cholesterol levels, and high blood triglycerides. One of the most important aspects of the water chestnut as a fruit is that it aids in blood pressure regulation due to its high potassium content. Research suggests that lowering the risk of stroke and blood pressure can lower the likelihood of developing heart disease. A study found that those with high blood pressure who drank more potassium had lower systolic and diastolic blood pressure by 3.49 mmHg and 1.96 mmHg, respectively, and had a lower risk of heart stroke. Another review of 11 research found that persons who consumed more potassium had a 21% decreased risk of heart attack and heart disease (Rani et al*.,* 2016).

4.2 Anti-oxidant Property

Water chestnuts contain a high level of total phenol, flavones, and flavonoids. The water chestnut fruit seed extract was found to contain carbohydrates, saponins, phytosterols, fixed oils, and fat, but the fruit pericarp extract contained tannins, flavonoids and glycosides, alkaloids, saponins, steroids, and phenol compounds (Hussain et al., 2018).

4.3 Anti-diabetic Property

Water Chestnut fruit peel extract shown anti-diabetic effects in streptozotocin-induced diabetic rats. One of the most noteworthy advantages is that the ethanolic extract of Water Chestnut roots and fractions can slow the progression of hyperglycaemia while preventing hypoglycaemia (Das et al*.,* 2011). The presence of ferulic acid and caffeic acid in Water Chestnut explains its anti-hyperglycaemic properties. Ferulic acid is known to minimize oxidative stress and hyperglycemic response, although caffeic acid has a generative effect on Langerhans islets as a result of decreased expression of glucose transporter 2 in the liver, which lowers hyperglycaemia (Corovic et al., 2021).

4.4 Anti-ulcer Activity

The study used Wistar rats to test the antiulcer capabilities of *Trapa bispinosa* fruits. The antiulcer activity of 50% ethanolic extract was evaluated at two dosage levels using the aspirin plus pyloric ligation and pyloric ligation plus pyloric ligation models. The test extract had significant antiulcer effect, possibly due to increased carbs and alterations in the stomach's mucosal barrier. The research suggests that *Trapa bispinosa* fruit extract (ethanolic) may have antiulcer potential (Kar et al., 2010).

4.5 Anti-microbial Property

Water Chestnut leaf extract has the potential to be used in microbial control because it is a rich source of biologically active chemicals. Antimicrobial activity was specifically demonstrated by the bacteria under examination. Pseudomonas aeruginosa and other gram-negative bacteria were especially susceptible to this effect (Radojevic et al., 2016). The anti-quorum sensing activity of Water Chestnut leaf extracts inhibits the manufacture of many virulence factors required for the progression of infection in P. aeruginosa, a pathogen (Aleksic et al*.,* 2018). As a reference, kanamycin was utilized by (Razvy et al*.,* 2011). To evaluate the antibacterial activity of fruit extract from two varieties of water chestnuts: green and red. The disc diffusion method was employed. The green variety of water chestnuts exhibited the highest antibacterial activity (12 mm) against both Shigella sonnei and Staphylococcus aureus, whereas the extract from the red variety exhibited a strong antibacterial potential (31 mm) against Bacillus subtilis.

4.6 Anti-inflammatory Property

Water chestnut extracts contained phenolic compounds such as gallic acid. Gallic acid appears to have antioxidant, anti-inflammatory, antiviral, and anti-cancer activities (Chuang et al*.,* 2010). Water chestnut extract contains gallic acid, which has a high anti-inflammatory effect and has been utilized in the treatment of skin inflammatory conditions (Kim et al*.,* 2015). *Trapa bispnosa* hydroalcoholic extract (500 mg/kg peroxidase) reduced fluorescence product and lipid peroxidation in the cerebral cortex of female albino mice while restored glutathione peroxidase and catalase function (Ambikar et al*.,* 2010). Using pyloric ligation and aspirin plus pyloric ligation models, (Kar et al*.,* 2010), Examined the antiulcer impact of a 50% ethanolic extract of *Trapa bispinosa* (Trapaceae) fruits on Wistar rats and discovered that the plant possesses potential antiulcer activity. When rats were exposed to sheep red blood cells (SRBC) as an antigen, (Patel et al*.,* 2010), examined the humoral immune response, cell-mediated delayed-type hypersensitivity reaction (DTH), and the percentage change in neutrophil count. They found that an aqueous preparation of *T. bispinosa* fruit increased the animal's humoral and cellular responses.

Image 1. Flowering

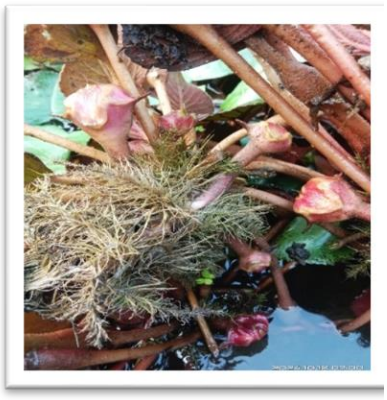

Image 2. Red Fruits

Image 3. -Green Fruits

Image 4 and Image 5. Water Chestnut Kernel

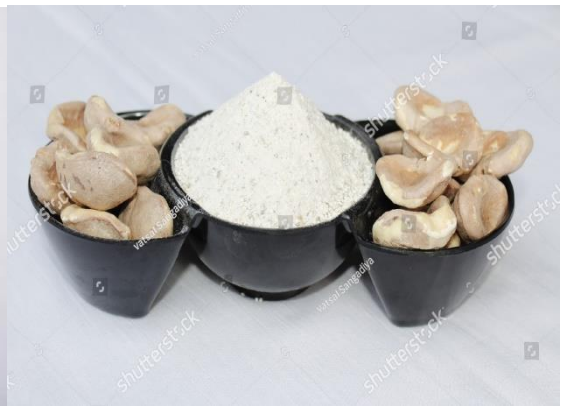

Image 6 and Image 7. Water Chestnut Flour

5. USES OF WATER CHESTNUT

5.1 As a Food

In the Indian subcontinent, water chestnuts, are used as a substitute for grains during fasting. In the case of wheat four (WF), which is associated with a problem with the digestion of gluten (a wheat protein), water chestnuts may be a preferable option. (Gul et al*.,* 2014 and Mir et al*.,* 2015). In India, on Navratri and other fasting days, water chestnut cookies are served as a specialty meal. Water chestnut four (WCF) holds great potential for the creation of gluten-free bread goods due to its high starch content and lack of gluten. Its varied nutritious qualities and high ber content further validate its use in the dishes. There is a rise in demand for water chestnut four cookies because to the higher spreading ratio of water chestnut cookies when compared to WF cookies.

Table 1. Nutrient profile of 100g of Water Chestnut (IFCT 2017)

Nutrient	Amount Per 100g
Protein	0.86 g
Carbohydrates	21.46 g
Total Fat	0.37 g
Energy	95.6 kcal
Calcium	37.15 mg
Phosphorous	62.83 mg
Iron	0.77 mg
Vitamin C	5.26 mg
Total Fiber	3.02 g

Table 2. Nutritional Value of Green and Red Variety (Rehman et al., 2024)

S.N.	Nutrient	Green variety	Red variety
1	Moisture (%)	70.23	68.74
2	Fat (%)	0.65	0.54
3	Starch (%)	19.52	21.99
4	Protein (%)	1.72	1.18
	Fiber (%)	2.21	2.04
Macro Minerals (mg/100 g)			
1	Na	3.11	2.51
2	Ca	49.27	34.20
3	K	392.02	315.01
4	P	132.04	118.00
Micro Minerals (ug/g)			
1	Fe	43.33	40.10
2	Mn	79.66	95.00
3	Zn	31.33	35.33
4	Cu	23.66	20.33

5.2 Value Added Products

Nutritious and gastronomic benefits can be obtained from value-added products made from *Trapa natans*, also called water chestnut. The plant's edible parts, the seeds or corms inside the spiky fruit, are usually processed into these goods. This list includes a few Water Chestnut items with extra value.

5.2.1 Production of gluten-free products

Chestnut flour is gluten-free and has additional health benefits, therefore it can be used by patients with celiac disease. Some scientists investigated the possibility of using chestnut flour instead of cow milk for making kid-friendly soups and desserts because lactose in cow milk might trigger allergic reactions in young children. Additionally, flakes, pasta, bread, baby formula, and milky puddings can be made with chestnut flour, per (Crow, et al., 2000 and Parekh et al., 2007). High in dietary fiber (4–10%), high in sugar (20–32%), high in starch (50–60%), high in protein (4-5%), high in essential amino acids (4-6%), and low in fat (2-4%) are all characteristics of chestnut flour. It also has high levels of magnesium, calcium, potassium, and the vitamins B, C, and E. It is thought that utilizing chestnut flour will help because most gluten-free products currently lack vitamin B, iron, and fiber. Because chestnut flour has so many nutritional benefits, it is also used to make gluten-free bread (Gani et al., 2010).

5.2.2 Water chestnut flour

Many researchers have previously investigated the physico-chemical characteristics of water chestnut flour and starch (Shafi et al., 2016; Gani et al., 2010). Water chestnut flour hasn't been thoroughly studied in terms of its functional, viscosity, thermal, and structural characteristics, which could indicate why it's a good fit for developing new products. Through a variety of biochemical interactions, starch interacts with other main and minor ingredients during food processing, determining the final product's overall desirability.

5.2.3 Water chestnut snacks

To make crispy, wholesome snacks, water hestnuts can be cut and dried. To improve the flavor of these foods, seasoning or flavoring is frequently added. Crisp and delicious, they're a healthier substitute for regular potato chips.

5.2.4 Canned or preserved water chestnuts

Water chestnuts with additional value are frequently canned or preserved. The water chestnuts are cut, peeled, and frequently kept in a light syrup or water. They give a crisp texture and a mild, somewhat sweet flavor to salads, stir-fries, and other foods, making them handy to use.

5.2.5 Water chestnut chips

Thinly sliced water chestnuts that have been deep-fried or dried to produce crispy chips are called water chestnut chips. Once seasoned, these chips can be eaten as a snack or added to salads and appetizers as a garnish.

5.2.6 Water chestnut syrup or concentrate

The juice or essence of water chestnuts is extracted to make water chestnut syrup or concentrate.It adds a distinct flavor to drinks, sweets, and mixed drinks when used as a sweetener.

5.2.7 Water chestnut paste

Water chestnut flesh is used to make a purée known as water chestnut paste. Particularly in Asian cuisines, it serves as a foundation for a variety of sweets and desserts. Dumplings, buns, and pastry fillings can be made with it by flavoring and sweetening (Mondal et al*.,* 2024).

6. DISCUSSION AND CONCLUSION

In conclusion, water chestnut emerges as a highly nutritious food with multiple health benefits. Its rich nutritional profile, combined with antioxidant, anti-inflammatory, and hydrating properties, positions it as a functional food that can contribute to disease prevention and overall health enhancement. As awareness of these benefits grows, further research is warranted to explore the mechanisms behind their health effects and to promote water chestnuts as a valuable component of a balanced diet. This exploration may lead to broader recognition and incorporation of water chestnuts in health-conscious culinary practices. It is probable that the use of water chestnuts in cooking will increase as more people become aware of their health advantages. The demand for this underutilized food may increase with more information and promotion about its nutritional worth, which could result in its incorporation into a range of food products and dietary supplements.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby state that no generative A.I. tools, such as Large Language Models (COPILOT, ChatGPT, etc.) or text-to-image generators, were utilized during creation and editing of this work.

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COMPETING INTERESTS

Authors have declared that no competing interests exists

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