



REVIEW BASED STUDY ON PHYTOCHEMICALS AND FUNCTIONAL PROPERTIES OF WATER CHESTNUT

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I. ABSTRACT

Water chestnut (*Trapa natans*, *T. bispinosa*) is locally named as singhara in india. It is an aquatic edible plant which is consumed all over the world in different forms because of its high medicinal, therapeutic and functional properties. It is a rich source carbohydrates, proteins, minerals, vitamins and certain bioactive compounds like phenols and flavonoids. It has great economic importance because of having high content of starch in its fruit. It is also the fruit of economically weaker section as it can be consumed as a vegetable, fried fritter, fruit, roasted nut or boiling. It can be used as substitute to many other grains like wheat because of its low gluten content and high nutritional value. The phytochemicals found in the water chestnut makes it an effective food for weight loss, diarrhea, bronchitis, dysentery, gastro issues and heart burning. It plays a vital role in the water purification of the wetlands like ponds and lakes. The bioactive compounds present in water chestnut have high quantity of antioxidants. The review mainly sheds light upon the nutritional composition, phytochemicals and functional importance of the water chestnut plant.

Key words: Water chestnut, medicinal, functional, bioactive compounds and antioxidants

II. INTRODUCTION

These are popularly known as nut but are described under the category of fruit, water chestnut is a plant of great purpose and usage along with being a pocket friendly. It has always been of great importance throughout the history. It is known with different names in different countries and is consumed widely by people all over the world. the availability of such super food with high nutritional value is an asset to the society as well as the food industry.

Water chestnut (*Trapa natans* L.) is called “singhara” and ‘paniphal’ in the local language of India. It is an aquatic nut that grows in the fresh waterbodies such as lakes and ponds. It floats on the surface of the wetlands (Kachare et al.,2016). It is highly cultivated in the states with high rainfall such as Orissa, Bihar, Uttar Pradesh and is widely consumed in these states during the festivals. It can be eaten in the form of vegetable, fruit, flour, roasted nut or snack. In India is majorly consumed during the fasting festivals due to its high nutritional value. It is a rich source of carbohydrates, proteins, mineral and vitamins along with amino acids. (Kachare et al.,2016).

All the parts of the plant possess different pharmacological and therapeutic properties. The stem of the water chestnut is submerged in the water bodies making a connecting sheath covering the surface of the ponds with intervals just under the leaf buds as stems also play a vital role in purification of water by decreasing the speed of currents and by removing the inorganic matter such as nitrate and phosphorus. Its flowers generally bloom in the afternoon and are white in colour, the flowers are bisexual and having four petals giving birth to the fruit in late June until September. The plant got its name from the formation of the fruit which is in the form of nut and has an outer covering of wooden like peel. The nut is in a triangle shape and has a starchy texture containing maximum amount of health benefits as it is a rich source of minerals such as calcium, magnesium, sodium, iron, copper, potassium. Also, the kernel consists of vitamins such as A, C, riboflavin, thiamine, D-amylase etc. along with having non-nutritional compounds which exhibit antioxidant properties. The pericarp extract of the fruit reveals presence of tannins, flavonoids and glycosides alkaloids, saponins, steroids and phenolic compounds. There is wide range of phytochemicals such as flavonoids, phytosterols, saponins, flavones, phenolic groups, tannins, glycosides and oils that are present in the water chestnut and hence making it a functional food. There are wide range of water chestnut varieties according to the different cultivation and climatic conditions (Vandana, kavya et al.,2015) (Shalini et al.,2019)

Bionomics:

kingdom	plantae
family	Tracheobionta
genus	Trapa
species	Trapa natans L.
Common name (India)	Singhara
Common name (English)	Water chestnut
Varieties (Indian)	T. bispinosa T. quadrispinosa T. bicornis

TABLE 1: CLASSIFICATION (B.R. Jana et al.,2020)

In addition, *T. bispinosa* exhibit major therapeutic as well as functional properties making itself a super food. It is of great value in Indian ayurveda and has been used to cure many diseases of stomach, liver, kidney etc. it is known as 'shrungataka' in ayurveda and is believed to have Madhura Kashaya rasa that is said to a fruit having its own sweetness and exquisite taste. Ruksha guru is the one that plays important role in digestion and is sheeta veerya which means that it is anabolic. Because of its variant roles it acts as a diuretic, antibacterial agent, antiulcer and has been used to treat diabetes, fungal infections and for the cooling effect during fever and summers. (Rosa, Jovana et al.,2020) (Dr. Abdul et al.,2020)

III. HISTORICAL BACKGROUND

Water chestnut is native to Eurasia where it was used in rituals, for decorations and medicinal purpose and was first introduced as a decorative and ornamental flora by Europe. The spread of the plant was very limited as its fruit was under water but still it was able to spread throughout the northeastern states. During the Chinese Zhou dynasty water chestnut had an important place as a food during worship for the prayer offerings. In the 2nd century BC, the rites in

Zhou dynasty used to follow the ritual of offering dried water chestnut by devotees in bamboo basket (Prafulla et al.,2014) (Ksenija et al.,2009)

Whereas, the water chestnut (*Trapa natans*) plant was first introduced in 1870s to north America which later came to knowledge that it was cultivated at Harvard University's botanical garden in 1877. Then, during 1879 the plant was found to be growing near the bank of Charles River. (Dr. Abdul et al.,2020)

IV. NUTRITIONAL COMPOSITION

Water chestnut is a rich source of carbohydrates, proteins, minerals and vitamins which makes it a fitting food to include in the diet of a person. The kernel of the plant is a gluten free, low-fat, low-sodium, without cholesterol and contains potassium, minerals, calcium, iron, zinc, phosphorous and fiber making it an excellent source of energy. On an average one cup of water chestnut fruit gives about 130 calories. (Singh et al.2011)

NUTRIENTS	PERCENTAGE
Moisture	60-70
Energy (kcal.)	110-115
Protein	4.40
Fat	0.65-0.84
Carbohydrates	22.30-24
Fibre	2.05-2.13
MINERALS	
Calcium	0.25
Potassium	5.30
Sodium	0.60
Phosphorous	6.77
Sulphur	0.35
iron	200ppm
Copper	440ppm
Manganese	100ppm
Zinc	600ppm
VITAMINS	
Vitamin C	1.1mg

TABLE 2: NUTRITIONAL VALUES OF WATER CHESTNUT (alfanse et al.,2011)

The whole fruit of the water chestnut is of great importance and is especially consumed during the fasting festivals in India. Along with above mentioned attributes the water chestnut is also a rich source of amino acids which makes it a crucial part of the human diet.

V. BIOACTIVE COMPOUNDS PRESENT IN WATER CHESTNUT

Phytochemicals or bioactive compounds are the constituents present in the fruits, vegetables, flowers that have nutritional values and provide with extra health benefits. These compounds are naturally occurring in the plants. They are the reason for a food to exhibit the antioxidant property, anticarcinogenic properties, anti-inflammatory properties and antimicrobial properties along with having a positive effect on the cardiovascular health, immunity etc.

Bioactive compounds include the flavonoids, anthocyanins, carotenoids, tocopherols, alkaloids, terpenes, saponins and phenolic compounds. (Charis et al.,2022, aytul et al.,2016)

A study done by rosa et al.,2020 it is evident that water chestnut has high percentage of phenolic compounds. *Trapa natans* species had 3 compounds which are gallic acid, ellagic acid, ferulic acid and quercetin 3-O-galactoside.

Gallic acid	63.81mg
rutin	21.34mg
tannin	17.11mg

Table 3: total content of phenolic, flavonoid and tannin compounds in water chestnut (rosa et al.,2020)

Phenolic compounds thus are defined as the plant constituents which have an aromatic ring bearing one or more hydroxyl group and these possess the benefits of averting the cell damage in human body done by free radical oxidation reaction. These compounds also possess the antioxidant property because of that these can inhibit the mutations of carcinogens in the human body. (Rosa et, al2020)

In the *Trapa bispinosa* variety of water chestnut a study revealed presence of saponins ($36.92 \pm 0.67\%$) and alkaloids were found to be $0.775 \pm 0.33\%$. saponins are known to enhance the defence mechanism against the diseases and stimulate the production of the t-cells and largely used in vaccinations and alkaloids exhibit the properties of the pain-relieving compound and cardioprotective properties. (Prafulla et al.2014)

Flavonoids are the phytochemicals naturally occurring in fruits, vegetables and belongs to the class of secondary metabolites. They have very distinct feature of promoting good health effects. They also have tendency to protect cells from the damaging effects of hydroxyl radicals. (Rosa et, al 2020)

Below are the bioactive compounds found in *Trapa natans* (Aleksic, I. et al. 2018)

PHENOLIC COMPOUNDS	FLAVONOIDS	
<ul style="list-style-type: none"> Gallic acid Protocatechuic acid Caffeic acid Ellagic acid Ferulic acid 	<ul style="list-style-type: none"> Quercetin Pinobanksin Naringenin Rhamnetin 	

VI. FUNCTIONAL IMPORTANCE OF WATER CHESTNUT

Trapa natans has known to be effective against many diseases which include diabetes, diarrhea, fever, sore throat, dental disorder, fatigues. Water chestnut has valuable phenolic compounds that tend to be useful in the treatment of many types of problems. It is used as an important ingredient in the preparations like appetizer, diuretic, tonic, nutrient, powders etc.

- **Antidiabetic activity:** Rosa et al., 2020 revealed in its study that peels of *Trapa natans* has shown antidiabetic activity in the diabetic rats. It is evident that ethanolic extract of water chestnut peels, roots can actually reduce the prognosis of hyperglycaemia. It is because of the presence of ferulic and caffeic acids which are the phenolic compounds. Caffeic acid has effect on glucose transporter to the liver which reduces the hyperglycemic effect whereas ferulic acid has an ability to reduce oxidative stress and glucose response. Another study done by Das et al., 2011, revealed that Wistar rats were injected with METN dose which increased their glucose tolerance in normal rats and in streptozotocin induced diabetic rats by decreasing and controlling the fasting blood glucose levels.
- **Analgesic activity:** A research revealed that Adult Swiss albino mice were injected by methanolic extract of *Trapa bispinosa* roots extract and then observed that they showed the analgesic activity against pentazocine. (Kachare et al.,) 2016. The dose of 200mg/kg and 400mg/kg were given to the mice along with the standard drug pentazocine at the dose of 30mg/kg.
- **Anti-microbial activity:** Water chestnut revealed to be having antibacterial properties. The study showed that *Trapa natans* fruit extract had maximum antibacterial property against gram negative bacteria. The method used for the experiment was the disc diffusion method. Two varieties of water chestnut were taken (red and green) where the red variety showed more antibacterial activity against *Bacillus subtilis* whereas green variety showed high antibacterial activity against *Staphylococcus aureus* and *Shigella sonnei*. (Prafulla et al., 2013) According to the study done by Rosa et al., 2020 *Trapa natans* peel extract also showed the antimicrobial property against *Pseudomonas aeruginosa* and *P. vulgaris*.
- **Anti-inflammatory activity:** As evident water chestnut contains gallic acid which is a phenolic compound and it is believed that gallic acid has therapeutic properties such as antioxidant, anti-inflammatory and anti-viral. Also, gallic acid is known to act against skin inflammatory disorders. (Rosa et al., 2020)
- **Immunomodulatory activity:** during a study the experimental animals were injected with aqueous solution of water chestnut and hence were studied for their cell mediated delayed responses like hypersensitivity reaction, humoral immunity response, and change in neutrophil count which revealed that *T. bispinosa* has the ability to enhance the response stimuli in the animals. (Baishali et al., 2020)
- **Hepatoprotective activity:** the ethanolic extract of *Trapa natans* fruit peel revealed the property of having hepatoprotection against the antitubercular drugs that cause hepatotoxicity. In the experimental animal's hepatotoxicity was induced by injecting the antitubercular drugs. Later, the aqueous extract of water chestnut peel was given which lowered the liver markers and resulted in antioxidant parameters. Later, it was also

shown that the root extract of water chestnut has protective effect against lipid peroxidation due to presence of ferulic acid and caffeic acid which makes it good antioxidant. (Rosa et, al 2020)

- Neuroprotective activity: a study revealed the effect of hydroalcoholic extract of *T. bispinosa* on the brain activity of female albino mice. The experimental animal was injected with 500mg of the extract which reduced the fluorescence build-up in the cerebral cortex of the mice. Additionally, the extract also heightened the lipid peroxidation and restored catalase activity of the cerebral cortex which enhanced the brain activity.

VII. VALUE ADDITION

water chestnut is a rich source of carbohydrates, proteins, minerals and all other important nutrients and hence can be used in different forms to enhance the nutritional and therapeutic value of the food products. The water chestnut flour can replace the wheat flour in the daily cooking making the roti's more nutritious and less sugary, along with the use of flour in puddings, cakes, breads can be a great asset to the food companies to introduce new product with more nutritional and market value.

The present of amino acids in the water chestnut kernel can combat the problem of malnutrition that is rising all over the world. Because of high nutritional value of the plant, water chestnut can replace many non-nutritional foods.

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