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SILVER NANOPARTICLE OF *TRAPA NATANS*: NUTRITIONAL AND PHARMACOLOGICAL ASPECTS (AN OVERVIEW)

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ABSTRACT

Silver nanoparticles in nanoparticulate system range in the size between 1-100nm. Silver nanoparticles synthesized from natural sources has a remarkable application in various fields of industry. Further, biological synthesis of Ag NPs from multiple herbal sources has been introduced to deal with certain drawbacks of physiochemical routes. The purpose of the foregoing review is to establish a biodegradable method to synthesize silver nano system using *Trapa natans* fruit. *Trapa natans* is a free floating aquatic plant grown in various parts of India, also commonly known as Singhara or water chestnut. The fruit consists of carbohydrates, flavonoids, starch, protein etc. In Indian Ayurvedic System of Medicine, *Trapa natans* has been recognized as a nutritive as well as cure to various diseases. The study also highlights the efficacy of kernels as antidiarrhoeal, appetizer, diuretic & tonic, in the treatment of STD, pregnancy. In this comprehensive review, green synthesis of Ag NPs of *Trapa natans* has also been covered and discussed for several other events like immunomodulatory, anti-bacterial, analgesic, anti-ulcer, anti-inflammatory.

KEYWORDS: Silver nanoparticles, *Trapa natans*, pharmacological activity, nutritional aspects, application.

1. INTRODUCTION

Nanoparticles are man-made, subsidiary or habitual material having one structural dimension where the particle size ranges from 1–100nm.[1] Nanoparticles are further sub-divided into organic and inorganic. Inorganic nanoparticles include semi-conductor nanoparticles (such as ZnO, CdS and ZnS), metallic nanoparticles (such as Au, Cu, Ag and Al), magnetic

nanoparticles (such as Ni, Co, Fe); whereas organic nanoparticles include carbon nanoparticles (such as quantum dots, carbon nano tubes, fullerenes,) gold and Ag (noble metal) nanoparticles.[2]

Over decades, silver has been used for multiple purposes in different forms. The drinkable water has been disinfected by storing it in a silver container owing to its antibacterial properties.[3] AgNPs have enormously been used as anti-bacterial agents in various health sectors, textile industries, food storage as well as disinfecting medical tools to potable water treatment.[4] Colloidal nanosilver was registered in the year 1954 in US which is prepared by suspending silver units in liquid. This preparation was used as biocidal material in the medication for almost a century[5,6] Antibacterial cold cream prepared from flower extract of Cassia auriculata was found to exhibit better antibacterial effect in comparison to the cold cream containing flower extract alone.[7] A notable nanoemulsions delivery method for AgNP was synthesized encapsulating DOX and final result concluded antibacterial effects together with antitumor efficacy, also effective in the treatment of cancer, thereby preventing microbial infection.[8]

Trapa natans (water chestnut) is an aquatic plant which grows yearly and the leaves are floating. This plant grows in freshwater such as lakes, ponds, wetlands etc. in India. Due to its exceptional and ethno medicinal properties, it is considered as one of the popular vegetables in current days. The fruit is considered as a marketable product cultivated in India, mainly in the Southern as well as Eastern region. Paniphal is broadly cultivated in Madhya Pradesh, Orissa, Uttar Pradesh and Bihar because of heavy rainfall.[9,10] Water chestnut is a free floating plant growing in fresh water. The roots spreads underneath soil while the leaves sink on top of aquatic layer. The stems elongate from the bottom to the surface of the water. The plant has rare qualities of heterocotyledon, heterophylly and heterorhizy. However, many studies have been conducted in terms of anatomy, physiology and roots.[11,12,13,14]

The herb comprises of minerals, magnesium, calcium, sodium, carbohydrates, phosphate, copper, iron, manganese and potassium. Inner part of seed, also known as kernels comprises of vitamins such as vitamin A, vitamin C, thiamine, nicotinic acid, D-amylase, riboflavin, and extensive quantity of phosphorylases. The fruit also contains considerable amount of phytochemicals viz. carbohydrates, flavonoids, flavones, total phenolic contents. The pericarp covers tannins, glycosides and flavonoids while the seed part has fixed oils, carbohydrates, phytosterols, fats and saponin.[15]

The fruit (water chestnut) are considered as astringent, appetizer, diuretic, nutrient, cooling, anti-diarrhoeal. It is also used in the treatment of rheumatism, sores or sunburns as a liniment.[16] *Trapa natans* shows effective immunomodulatory activity[17], analgesic[18], anti-inflammatory[19], anti-diabetic[20], antibacterial[21], antiulcer activity.[22]

Silver nanoparticles of aqueous *Trapa natans* leaf extract showed strong cytotoxic activity against A431 skin cancer cell line.[23] Au-Ag nanoparticles derived from T. natans peel extract considerably enhanced ROS that triggered p53-independent aptosis in numerous cancer cells efficiently.[24]

2. HABITAT

Trapa natans, belonging to the family Lythraceae, is an aquatic suspended herb under the kingdom Plantae and sub kingdom Trachebionta.[25] The stems are flexuous, rising uphill in the water; the water-logged parts has multiple reverse pairs of scattered root-like pectinase structure. The leaflets are alternatively crowded on the top of the stem of about 3.8-5cm long, rhomboidal shaped, reddish-purple underneath and the petiole is dilated adjoining the apex. Flowers grow in limited numbers, auxiliary, solitary, white in colour. The fruits are about 2.5cm long of ovoid or angular shape, with sharpened edge horn at either side. *Trapa natans* is locally known as water chestnut and is commonly grown throughout India.[26] Apart from its importance in aquatic ecosystems, this species are edible in India, China and Southeast Asia. Because of its therapeutic value the fruit along with herb has tremendously been accepted in urban culture as a procurement to various ailments.[25]

3. HISTORICAL PERSPECTIVES

In 1870s *Trapa natans* was first recognized in North America which was later identified to have been grown at Harvard University in a botanic garden in the year 1877. In 1879, the herb was then found budding in the bank of Charles River. *Trapa natans* resembles much of a patterned ornate plant from Europe. The plant is large with skinning nuts which limits the dispersion of the plant. The plant is available in Northeastern states as well. In the Chinese Zhou Dynasty, water chestnut was considered as a vital foodstuff in devotion as an offering. The rites of Zhou (2nd century BC) cited to follow the tradition of practicing bamboo basket by a devotee containing dried water. It grows in fresh water lakes and well-known as singhada or paniphal in India.[27]

4. BOTANICAL DESCRIPTION

Taxonomical Classification **(**Prafulla et al., 2014**)**	***Vernacular Names*** (Prafulla et al., 2014)
Kingdom : Plantae ***Family*** : Lythraceae ***Genus*** : Trapa; L.	***English*** : water chestnut ***Sanskrit*** : smgtakah; jalphala ***Hindi*** : singhara; singhada ***Assamese*** : paniphal

5. CULTIVATION AND COLLECTION

The seeds of *Trapa natans* are planted generally during the month of May and June in a constant water. The organic stuff already available in the soil helps the plant to grow better. And the common carp fingerlings are maintained till the month of September-October. The fruits matures during winter season and are collected in the month of November-January.[27]

6. TRADITIONAL USES

Paniphal has been recognized in the Ayurveda system as **Shrungataka.**[28] Shrungataka is a valuable medication cited by most of the Ayurveda lexicons, vocabularies, with reference to its various properties and how it acts. The few common synonyms of Shrungataka are Jalakanda – considering its aquatic property, Trikona kanda - considering its triangular shape. The drug is also believed to retain Madhura Kashaya rasa (owing to its sweetened and astringent taste), is Ruksha Guru (dry and heavy for digestion), it is Sheeta veerya (cold in potency, anabolic in nature). It also reduces the vitiated Pitta dosha (One of the three bio forces responsible for the metabolism). Hence, Shrungataka is able to treat several ailments triggered by Pitta dosha.[29] Shrungataka can be used as a diuretic and also pittahara as a treatment to its indication as well as etiology.[30] The drug can also be used as a haemocoagulant, mostly in Post partum haemorrhages.[31] Gandha taila is considered as one of the most crucial medicines in Ayurveda for fractures and also helps in bone strengthening.[32] Other formulations of Ayurveda along with the drug (Shrungataka) is prescribed in Shiroroga (diseases related to Head), Eladi taila given in case of fractures, Vrushya ghruta and Apathyakarasvarasa given as aphrodisiacs.[33] In Visarpa (Erysipelas), a paste of shrungataka with few other pittahara dravyas can be applied with ghee.[34]

7. CHEMICAL COMPOSITION

Water chestnut consists of phytosterols, carbohydrates, fixed oils, flavonoids, glycosides, saponins present in the pericarp of fruit which was further standardized by Thin Layer

Chromatography studies. *Trapa natans* consists of both organic and inorganic constituents listed below:

Biochemical analyses of *Trapa natans* fruit revealed the presence of both carbohydrate, phosphorus and protein dry and fresh fruits, respectively. It also contains few percentage of fat, fiber, ash and moisture. Study revealed both fresh as well as dry seeds produces abundant amount of energy.[35]

Organic constituents includes vitamins and carbohydrates viz. Vitamin B-complex (pyridoxine, thiamine, riboflavin, pantothenic acid, nicotinic acid), vitamin-C, amylase, D-amylase, vitamin-A and phosphorylase. It also contains 2β, 3α, 23-trihydroxyurs-12-en-28-oic acid, Cycloeucalenol and ursolic acid.[36]

8. NUTRITIONAL ASPECTS

On the basis of the previous studies, the nutrient composition of paniphal fruit showed the presence of crude fiber, ash, moisture, total soluble sugar, lipid, reducing sugar, non-reducing sugar, reducing sugar, and starch. Both the green and red variety of water chestnut consists of total phenol, water soluble protein, vitamin-C, and beta-carotene. Mineral contents were found to be potassium, zinc, phosphorus, iron, copper, sulphur and manganese. Both varities were commonly found to have tryptophan, free amino acids, leucine, tyrosine, alanine, glutamic acid, and lysine. In contrary, green and red varieties were found to contain glutamine, proline, asparagines cysteine and arginine respectively. Therefore, the recent learning highlights the nutrient composition of green and red varieties of water chestnut as well as it establishes that water chestnut is highly nutritious in human life.[37]

9. UTILIZATION

Fruit is considered as a crucial basis of food chain system, considerably during the period of scarcity. The fresh warm kernels resembles more like water chestnut flavor. Fruits are the basic source of nutrition, well as sweet and delicious. The nuts are eaten raw or after cooking or boiling or roasting it. The dried kernels are grinded to prepare meal which can later be used as an alternate for cereal flour.[38] The kernels are reported to contain proteins, fats, fibers, other carbohydrates, mineral matters viz. iron, copper, iodine, phosphorus, calcium, magnesium, potassium and vitamin contents viz. vitamin A, riboflavin, thiamine, vitamin C, nicotinic acid. The study has also showed the presence of phosphorylase, tannins and β-amylase in the kernels.[38]

9.1.Usage as a food

Water chestnuts are aquatic vegetables that are nutritious and delicious. Water chestnuts are believed to be versatile owing to its diversity in multiplicity of dishes. The fruits are either dried or ground to flour, occasionally given as an alternate for arrowroot flour or can be boiled or roasted. The fruits are considered to be nutritious which contains 2% protein and 21% starch. The fruits are crispy and juicy when raw, the white inner part can be enjoyed raw or cooked. Water caltrops taste similar to potatoes. Upon cooking, the flesh softens while the inner part still remains crunchy.[39]

9.2.Usage as medicine

Interestingly, water chestnut is considered as a valuable ingredient in various preparations such as astringent, appetizer, diuretic, tonic, nutrient, chilling effect, and anti-diarrhoeal. Fruits can be used in ointment preparation as a treatment of sunburns, sores and rheumatism. It is also useful in certain circumstances of bronchitis, inflammation, sore throat, fatigues etc. The juicy preparation is useful in the treatment of eye infection.[16]

9.3.Usage in traditional treatment

Unani medicine: In ancient days, water chestnut was used in Unani system to treat irregular fever, sore throat, dry cough, weakness, fatigue, TB, dental disorders and various other sexual disorders such as sexual frailty, spermatorrhea etc.[16]

9.4.Usage during Fertility, Pregnancy and STD

Water chestnut lotus can be taken in case of itching of breast, lower abdomen, thigh. Water chestnut fruits mixed with milk are used in general and nervous weakness, leucorrhoea, confectionary prepared is prescribed in 2-4 doses. In ancient days, hakims used to recommend it as a powder, thus taking water chestnutt, kamarkas(kino) and white sugar. 7parts were made out of it while suggesting 1 part everyday.[40]

9.5.General uses[41]

i. The powder of dried fruit/seeds of water chestnut is highly used in the preparation of breakfast because of its nutritious properties.
ii. The powdered compound is used to treat polyuria, oedema. It also controls bleeding.
iii. The powdered compound strengthens body and used as a supplement in muscle weakness.
iv. The powder is also used to treat women suffering from threatened abortion.

10. PHARMACOLOGY

10.1. ***Immunomodulatory activity:*** The immunomodulatory effect of water chestnut was evaluated in rats contrary to sheep RBC as antigen. Macrophage phagocytosis assay was evaluated in mice by carbon clearance method. Delayed hypersensitivity reaction showed a gradual increase by augmenting the mean foot pad thickness at an interval of 48hrs. The study concluded that the aqueous extract of *Trapa natans* could stimulate the humoral and cellular response in animals.[17]

10.2. ***Analgesic Activity:*** To evaluate the analgesic activity, the methanolic extract of the *T. bispinosa* root was carried out in Swiss Albino mice by tail flick and tail flick and tail immersion method. The results indicated gradual analgesic activity against stimuli after an interval of 45 minutes in tail flick method and 30 minutes in tail immersion method respectively.[18]

10.3. ***Antidiabetic Activity****:* Antidiabetic activity of *Trapa natans* fruit peels of methanolic extract was studied in Wistar rats. The study showed that METN dose dependently increased oral glucose tolerance in normal rats and in STZ-induced diabetic rats by decreasing and thereby controlling the increased the fasting blood glucose levels.[20]

10.4. ***Antibacterial Activity****:* Antibacterial activities of the fruit extract of two varieties (green and red) of *Trapa natans* was performed by the disc diffusion method from methanol extract. In this study, the green variety was found to have less antibacterial efficacy in comparison to the methanolic extract of red variety.[21]

10.5. ***Antiulcer Activity:*** The antiulcer activity of *Trapa natans* fruits was carried outr on Wistar rats. The studies were conducted by using aspirin plus pyloric ligation model and pyloric ligation model. The final result concluded the antiulcer activity due to the rise in total carbohydrate content and also the modified state of mucosal barrier of the stomach.[22]

10.6. ***Antibacterial Activity:*** Antibacterial activities of the methanolic fruit extract of two varieties (green and red) of *Trapa natans* was studied by the disc diffusion method. The final finding established that red variety has greater antibacterial efficacy in comparison to that of green variety extract.[20]

11. PHARMACEUTICAL APPLICATIONS

11.1. Freeze thaw stability

Water chestnut starch from different plants (lakes) were collected and final result showed that the stability of gels increases upon addition of salt. Upon addition of NaCl at 0.5%, 1%, and 2% showed maximum stability in comparison to other salts due to the presence of hydrophilic nature of the sodium chloride which led to the increase in stability of the mixtures in contrary to freeze thawing at varied concentration.[42]

11.2. Pasting property

In water chestnut starches, the viscosity rate was found to increase with gradual rise in temperature. The viscosity enhancement with rise in temperature could be attributed as a result of water removal from the exuded amylose as they swelled. The pasting properties depend on the rigidity of starch granules, as a result which affecting the granule swelling point and amount of amylase leaching out in the solution.[43]

11.3. Excipients

Starch obtained from water chestnut has remarkable binding and physiochemical activity than that of the official one. Physiochemical property was compared with potato starch and maize. The form is basically round. Water chestnut starch has approximately similar hydration and swelling capacity which makes it as one of the potential excipients in pharmaceutical formulation development. It can also play the role of binder in various formulation.[43]

CONCLUSION

The methodical literature review of Unani, Ayurvedic system directs that *Trapa natans* plays a significant role to treat polyuria, diarrhoea, dysuria, sexual and general debility, fever, STD, sore throat etc. The various pharmacological studies of silver nanoparticles derived from the water chestnut reveals the importance of immunomodulatory, anticancer, analgesic, antibiotic, antidiabetic activities. The interest towards nanoparticle formulation from herbal sources is globally increasing due to its ecofriendly nature and limited adverse effects. This study aimed to develop an added value pointing *Trapa natans* as a safe and currently effective plant having diverse medicinal applications and nutritionally beneficial.

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