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# Nutritional and Therapeutic Potential of Makhana *(Euryale ferox* Salisb) based Traditional Delicacies and Their Ethnic Significance: A Narrative Review

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## ABSTRACT

Makhana seeds often hailed, as a "super food " is renowned for its high energy, nutritional value and therapeutic benefits. Deeply rooted in Indian culture, makhana has been a cherished part of traditional festivals and culinary practices for centuries. Bihar (India) stands as a hub for makhana cultivation, sustaining this heritage over generations. Makhana is widely used to prepare a variety of several traditional healthy cuisines, including curry, laddu, kheer, panjiri and khoa based sweets. It also holds special significance as a nutrient-dense food consumed during religious fasts in Hindu culture. This review paper explores the ethnic significance, nutritional profile, therapeutic benefits and functional properties of makhana-based delicacies. Key health benefits include its cardio-protective effects, anti-diabetic properties, immuno-stimulant capabilities, anti-ageing properties and anti-depressant and antioxidant properties. By shedding light on these aspects, the article aims to raise global awareness about makhana's traditional culinary applications and encourage its inclusion in diverse diets through the development of innovative, value-added food products.

**Key words:** Ethnic, Makhana, Nutritional properties, Therapeutic potential, Traditional delicacies.

*Euryale ferox* Salisb, commonly known as makhana, fox nut, lotus seed and gorgon nut, is an aquatic food crop primarily cultivated in ponds (Sidh and Sharma, 2019). Belonging to the family *Nympheaceae*, it is a stemless perennial plant with large round leaves and bright purple flowers, thriving in swampy and marshy areas with stagnant water (Jana *et al*., 2018). Its high energy, carbohydrate, good quality protein contents and low-fat composition make it a sought-after food, especially for religious offerings (Fig 1).

Makhana is widely cultivated in Japan, Korea, Russia, North America, Nepal, Bangladesh and India. Within India, it is mostly cultivated in the northern and northeastern regions, with commercial cultivation concentrated in Bihar, Manipur, West Bengal and Madhya Pradesh (Kumar *et al*., 2016). Bihar alone contributes approximately 80% of India's total makhana production. The edible part of the plant, perisperm (starchy kernel), is extracted by popping the hard seed coat through traditional methods (Sundarraj *et al*., 2017).

Makhana is a perennial aquatic plant cultivated as a seasonal crop that dies out after its fruit matures. Upon maturation, the fruit coat raptures, dispersing seeds at the bottom of the water bodies. These seeds are collected and processed into ready-to-eat white puffs by frying them in a hot earthen oven. Post-harvest processing involves sun drying, size grading, preheating, tempering, roasting, popping, polishing, grading and wrapping (Mandal *et al*., 2010). In India, Makhana is consumed in various forms-raw puff, cooked in stews, or as grounded flour for weaning food. It is also a key ingredient in sweet dishes, pudding (*Makhana Kheer* or *Makhana Payasam*), snacks and curries (Nehal *et al*., 2015). In the Hindu culture, Makhana holds religious significance, often used in rituals and as a nutritious food during religious fasts.

The therapeutic properties of makhana seeds are well documented in ancient Indian and Chinese literature (Francis, 2019). It is also valued for its role in preventing micronutrient deficiency diseases, protein-energy malnutrition

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and lifestyle disorders (Mandal *et al*., 2010). Due to its nut-like flavor, versatile sensory qualities and functional properties, makhana has traditionally been incorporated into numerous healthy culinary preparations, promoting overall health and well-being. With increasing health consciousness among consumers, the food and health industries have started adopting and innovating traditional cuisines into value-added food products. In recent years, ethnic foods like makhana have gained commercial significance as nutrient-dense options in the global healthy food market. Makhana, rich in carbohydrates, unsaturated fats, high-quality protein, dietary fiber and essential micronutrients such as calcium and magnesium, is a prime example of functional food with significant health benefits (Jana and Idris, 2018). Makhana seeds have been widely recognized towards people as functional traditional nourishment food during Covid-19 (Jana, 2021). Makhana encompass good source of starch, magnesium and amino acids particularly arginine, histidine, lysine and methionine. Moreover, makhana is endowed with anti obesity, anti-diabetic and helps in preventing hypothyroidism disorder (Jana, 2025).

Despite growing scientific interest in makhana (*Euryale ferox*) due to its recognized nutritional and functional properties, existing literature reveals several critical gaps, particularly in narrative reviews that integrate its ethnic significance with its nutritional potential. A focused narrative review would contribute to a more holistic understanding of makhana, promote culturally informed nutrition education and support future research at sustainable and traditional food systems. This paper is needed to bridge tradition and science, validate ethnic food wisdom and unlock makhana's full therapeutic and socio-cultural potential in a modern context.

This review paper aims to highlight and popularize the nutritional characteristics, ethnic significance and functional properties of makhana-based traditional Indian delicacies on a global scale, encouraging wider adoption and innovation in its use.

## Nutritional properties of makhana seeds

Makhana seeds are a nutrition powerhouse, offering a wide range of wellness benefits. Raw makhana seeds also known as "black diamonds" in raw form, are manually popped using traditional methods to extract their starchy kernel, the edible portion of the seed. The calorific value of raw makhana seeds is 362 kcal/100g, while popped makhana seeds have a slightly lower calorific value due to the popping process (Sundarraj *et al*., 2017). Remarkably, the calorific value of popped makhana seeds is comparable to staple foods like rice and wheat.

In terms of macronutrient composition, makhana kernel powder also rich in carbohydrates, protein with low fat content. It is also a rich source of essential micronutrients like macro and micro minerals. (Jana *et al*., 2019). Additionally, makhana provides significant amounts of ascorbic acid, sugar and phenolic compounds. Although makhana's protein content (10-12%) is lower than that of cereals, it is more nutritionally dense compared to other plant-based foods. The essential amino acid index (EAAI) of makhana is 93%, surpassing cereals and even some animal products in nutritional quality (Jha *et al*., 1991). Furthermore, its arginine-lysine/proline ratio (4.74-7.6) is higher than that of other cereals, attributed to a favorable leucine-to-isoleucine ratio. However, the biological value of popped makhana seeds (55) is lower than many plant- and animal-based foods, suggesting its optimal use as a complementary food (Shankar *et al*., 2010).

Makhana is an excellent source of essential amino acids, including glutamine, arginine, leucine, isoleucine, cysteine and methionine. These amino acids not only function as antioxidants but also serve as precursors for long-chain amino acids, contributing significantly to overall well being (Jana and Idris, 2018).

Popped makhana seeds is an ideal food choice, offering high carbohydrate content high-quality protein and excellent macronutrient digestibility. They boast a high starch digestibility index (42.3±0.3) and protein digestibility (84.2±2.36%), making them a nutrient-dense option. With low sodium and fat content, makhana puffs are well-suited for inclusion in low-sodium and low-fat diets. Additionally, their low bulk density and high water absorption capacity make them a versatile ingredient for baked goods and complementary foods (Haleema *et al*., 2018). Roasted makhana seeds are rich in carbohydrate, protein, potassium, iron and zinc and low in sodium content as compared to raw and popped seeds (Liaquat *et al*., 2022). The nutritional composition of makhana seed is given in Table 1.

## Therapeutic potential of Makhana seeds

### Cardio-protective effect

The cardioprotective properties of makhana are attributed to its ability to induce proteins like TRP32 (thioredoxin-related protein-32) and Trx-1 (thioredoxin-1) while scavenging reactive oxygen species (ROS). In vitro studies by (Das *et al*., 2006) demonstrated the cardioprotective effects of makhana extract using antibody array techniques in rat models, showcasing its potential to mitigate oxidative stress.

### Anti-diabetic effect

Diabetes and its complications are closely linked to oxidative stress caused by free radical generation. (Ahmed *et al*., 2015) identified makhana seeds as a functional food with significant antioxidant, anti-diabetic and anti-hyperlipidemic properties. Ultrastructural and histopathological studies confirmed that makhana seeds protect β-cells from ROS-induced damage by enhancing antioxidant activity and reducing hyperglycemia. Additionally, its antioxidant properties are effective in preventing complications such as proteinuria and diabetic nephropathy (Song *et al*., 2011).

### Anti-depressant effect

Depression, a globally prevalent mental health disorder, is often linked to decreased autophagy. The petroleum

ether fraction of *Euryale ferox* (ES-PE) has emerged as a natural antidepressant. Studies using a chronically unpredictable mild stress mouse model revealed that ES-PE exerts antidepressant effects by positively regulating autophagy through the Adenosine Monophosphate-Activated Protein Kinase-UNC-51-like kinase 1 (AMPK-ULK1) pathway (Huang *et al*., 2018).

**Anti-aging property**

Makhana's anti-aging benefits stem from its rich amino acid profile. It contains high levels of anti-aging amino acids like glutamine, cysteine, methionine and arginine. The significant glutamine/glutamic acid content in popped makhana (17.06%) contributes to its remarkable anti-aging effects. Furthermore, amino acids such as arginine and methionine serve as precursors for creatine, which is essential for healthy skin, nails and hair (Jana and Idris, 2018).

**Immuno-stimulant activity**

Makhana seeds are effective immune stimulants. Both raw and popped makhana powders enhance humoral immunity, also known as antibody-mediated immunity. This property is particularly beneficial for women during the postnatal stage, providing crucial hormonal support (Puri *et al*., 2000).

## Ethnic significance of makhana-based traditional Indian delicacies

In India, makhana has been an integral part of cultural traditions and festivals for centuries. Recently, it has gained popularity in Western countries, largely due to its high nutritional value and numerous health benefits. The Mithila region of North Bihar (India) is particularly renowned for the organized cultivation of makhana, a practice sustained over generations.

Makhana holds significant religious and cultural importance in India, especially among the Hindu community. It is widely used in religious ceremonies and rituals such as marriages, worship services and last rites (*Shraddha Karma*) (Kumari and Jha, 2018). In the Koshi and Mithila regions, makhana is an essential component in marriage rituals like *Gauna* (when the bride moves to her husband's home after marriage) and *Kojagara Puja* (a ceremony dedicated to Goddess Lakshmi). Similarly, Sikh communities incorporate makhana in *tilak* ceremonies (a pre-marriage ritual), often pairing it with other dry fruits.

In Bihar, makhana pops are indispensable for *Chhath Puja*, an important festival where offerings are made to the Sun God. As a non-cereal food, makhana is also a preferred choice for those observing fasts during festivals such as *Navratri* and *Durga Puja*. Furthermore, in the Muslim community, makhana is consumed in various forms during *Ramzan* (Sodi and Kumar, 2019).

Culinary traditions in India also celebrate makhana in a variety of ways. It is commonly used to prepare snacks, curries, sweet dishes, desserts and *prasad* (holy offerings to deities) such as *panch amrit* and *panch mewa*. The following section highlights some of the traditional makhana recipes enjoyed across different regions of India.

## Makhana kheer

Makhana Kheer is a traditional Indian milk pudding cherished for its rich taste and creamy texture. It is prepared by roasting makhana in ghee (clarified butter) until aromatic and then blending it into a coarse powder. The roasted makhana is cooked in boiling milk along with sugar and dry fruits until the milk thickens and develops a creamy consistency (Fig 2a).

To enhance the flavor and appearance, nutmeg powder and saffron strands are added, giving the dish a distinct aroma and golden hue. Makhana Kheer is commonly consumed as *prasad* (a holy offering) during festivals and religious occasions such as *Shivratri*, *Navratri*, *Ekadashi* and on fasting

**Table 1:** Nutritional value of makhana seeds.

| Parameters | Raw seeds (Kumar *et al*., 2016) | Popped seeds (Kumar *et al*., 2016) | Roasted seeds (Liaquat *et al*., 2022) |
|---|---|---|---|
| Moisture % dry basis | 34.7 | 10.4 | 4.17 |
| Total ash % dry basis | 0.3 | 0.4 | 0.66 |
| Fat % dry basis | 0.3 | 0.5 | 0.68 |
| Protein % dry basis | 7.2 | 8.7 | 14.57 |
| Crude fiber % dry basis | 0.5 | 0.2 | 0.51 |
| Carbohydrate% dry basis | 57.0 | 79.8 | 79.4 |
| Phosphorus mg/100 g | 66.1 | 53.2 | 56.4 |
| Potassium mg/100 g | 35.6 | 42.0 | 47.2 |
| Iron mg/100 g | 0.8 | 1.4 | 12.7 |
| Calcium mg/100 g | 9.5 | 18.5 | 19.2 |
| Magnesium mg/100 g | 11.3 | 13.9 | 26.3 |
| Sodium mg/100 g | 48.2 | 71.0 | 23.8 |
| Copper mg/100 g | 0.3 | 0.5 | - |
| Manganese mg/100 g | 0.9 | 1.3 | - |
| Zinc mg/100 g | 0.9 | 1.1 | 1.8 |

days after religious ceremonies. Its rich nutritional profile and delectable taste make it a favorite among festive dishes.

**Panch-mewa**

Panch Mewa, a term derived from Hindi, refers to a mix of five dry fruits that holds immense significance in Hindu religious ceremonies. This tradition has been followed since ancient times, symbolizing the *Panch Tatva* (five fundamental elements of life): *Akash* (sky or space), *Vayu* (air), *Jal* (water), *Agni* (fire) and *Prithvi* (earth). The five dry fruits typically included in Panch Mewa are almonds, raisins, dry coconut, makhana and dry dates. These are often arranged on a *pooja thali* (worship plate) and offered to deities during rituals and ceremonies (Fig 2b).

Due to their high energy and nutrient content, Panch Mewa is also an integral part of religious fasting. Devotees consume it to sustain energy and fulfill dietary needs while observing fasts, making it both a spiritual and nutritional component of religious traditions.

**Panchamrit**

Panchamrit, derived from Sanskrit where "Panch" means "five" and "Amrit" translates to "the elixir of gods," is a sacred mixture traditionally used in Hindu religious ceremonies across India. This divine concoction symbolizes purity and nourishment and is believed to confer blessings and spiritual vitality.

The preparation of Panchamrit involves five holy ingredients: yogurt, cow's milk, honey, ghee (clarified butter) and basil (*Ocimum sanctum*). In some regions, makhana is also included, enhancing its texture and nutritional value. Each ingredient holds symbolic and spiritual significance, representing health, prosperity and divine grace. Panchamrit is offered to deities during rituals and subsequently distributed as *prasad* among devotees, who consume it as a sanctified blessing at the conclusion of the ceremony (Fig 2c).

**Makhana laddu**

Makhana Laddu is a beloved Indian sweet dish, cherished for its rich taste and nutritional value. Prepared from roasted makhana puffs, the ground makhana is further roasted in ghee (clarified butter) to enhance its flavor. It is then combined with sugar or jaggery syrup to bind the mixture, with dry fruits such as almonds and cashews added for added texture and nutrition. The mixture is shaped into sweet, bite-sized balls known as laddus.

These laddus are traditionally offered to women during pregnancy, as their nutrient-rich ingredients are believed to support fetal development. Additionally, Makhana Laddu is a staple delicacy during festivals and religious occasions, symbolizing both celebration and nourishment (Fig 2 d).

**Fig 1:** (a) Raw seeds and (b) puffed makhana.

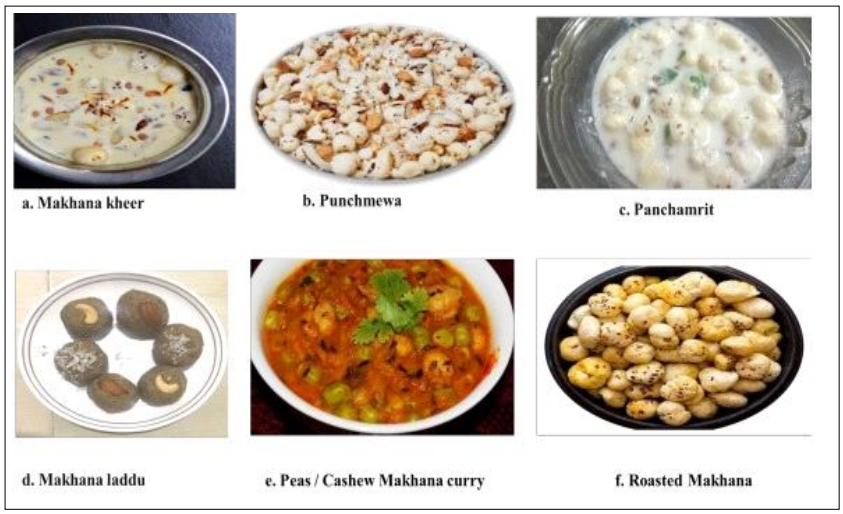


**Fig 2:** Culinary preparations from makhana seeds.

### Peas makhana curry

Peas Makhana Curry is a flavorful and wholesome Indian dish made with rich and aromatic gravy of ginger, garlic, onion, tomato and an array of spices. The curry features makhana, peas and cashews, creating a delightful blend of textures and flavors.

This dish is commonly served during Hindu marriage ceremonies as a versatile curry enjoyed by both vegetarians and non-vegetarians. For those observing fasting during festivals like *Navratri* or *Janmashtami*, a variation of this curry, known as Cashew Makhana Curry, is prepared without onion and garlic, adhering to fasting dietary customs. Makhana Curry is cherished for its delicious taste and nutritional value, making it a popular choice for both celebratory and religious occasions (Fig 2e).

### Roasted makhana seeds

Roasted Makhana is a widely loved homemade evening snack known for its simplicity, taste and health benefits. It is prepared by roasting makhana puffs in a small amount of ghee (clarified butter) and seasoning them with a blend of spices such as black pepper and turmeric powder (Fig 2f). This crunchy and flavorful snack is not only a quick option for everyday munching but is also a preferred choice during fasting periods, especially during religious observances like *Navratri*, *Shivratri* and *Ekadashi*. Its light texture and nutritious profile make roasted makhana an ideal snack for both regular consumption and special occasions.

### Makhana panjiri

Makhana Panjiri is a traditional Indian delicacy prepared by roasting makhana in ghee (clarified butter) and grinding it into a coarse powder. The powdered makhana is then mixed with powdered sugar and enriched with dry fruits such as almonds, cashews and raisins.

This nutrient-dense dish is commonly consumed during fasting periods, including *Janmashtami*, *Shivratri*, *Navratri* and *Ekadashi*. It is also often offered as *prasad* (a sacred offering) after religious ceremonies. In addition to its role in religious and fasting diets, Makhana Panjiri is enjoyed during non-fasting periods as a wholesome snack and is also considered a suitable weaning food for infants, owing to its rich nutritional content.

## Value addition of makhana seeds based foods

Popped makhana seeds hold significant potential as a raw material for developing value-added food products due to their exceptional nutritional and functional properties. Here are some innovative uses:

### Bun/Bread

Popped makhana can enhance the nutritional value and texture of baked goods like buns and bread. According to (Kumar *et al*., 2014), incorporating up to 15% popped makhana flour with wheat flour yields bakery products with improved quality and health benefits. The increased water absorption capacity of makhana flour and its modified starch structure contribute to higher product quality and yield.

### Cookies

Cookies enriched with popped makhana flour have been found to be nutritionally superior. (Kumar *et al*., 2015) noted that adding up to 25% makhana flour to wheat flour produced cookies with acceptable sensory qualities. However, exceeding this proportion led to a noticeable decline in sensory scores.

### Infant food

The hygroscopic properties and rich nutritional profile of makhana make it ideal for infant food formulations. A ready-to-mix infant food prepared with 40% puffed makhana flour, 40% samak rice and 20% banana flour is highly beneficial. This formulation is easy to digest, low in protein and packed with minerals like calcium (180 ppm), iron (23.75 ppm) and zinc (12.50 ppm). Moreover, the product is rich in phytochemicals and antioxidants, supporting infant health and growth during early development stages (Bana and Gupta, 2015).

### Composite flour

Composite flour made from a blend of wheat flour and popped makhana flour (5-25%) enhances protein content while reducing fat content. As reported by Kumar and Saini (2016), increasing the proportion of makhana flour improves the water solubility index and oil absorption index. The latter is particularly important for baked goods, as it helps retain flavor and enhances mouthfeel.

These applications demonstrate the versatility and health benefits of makhana, making it a valuable ingredient in developing nutritious and functional food products.

## Use of makhana seeds in traditional medicine

Makhana has a long history of use in traditional medicine, with documented applications in ancient Indian and Chinese medical systems (Francis, 2019). Its functional properties-such as antioxidant activity, aphrodisiac effects and benefits for reproduction, cardiovascular health and diabetes management-underscore its medicinal value.

### Ayurvedic medicine

In Ayurveda, makhana is valued for balancing the Vata (space and air) and Pitta (fire and water) doshas while increasing the Kapha (water and earth) dosha. Its therapeutic formulation, *Paustik Churna* (healthy powder), is widely used for various health benefits. By reducing Vata and Pitta doshas, makhana is believed to support fertility in women. Due to its Pitta-reducing properties, it strengthens the heart and enhances overall energy levels. Ayurvedic practitioners recommend consuming 5-10 grams of makhana seed powder twice daily for optimal benefits (Sidh and Sharma, 2019; Masram *et al*., 2015). (Raut *et al*., 2018) reported that a daily intake of 30 grams of shallow-fried makhana in 1-2 teaspoons of ghee, combined with lukewarm milk over 45 days, improved physical (*e.g*., fatigue, backache, abdominal pain), physiological (*e.g*., uterine recovery, bleeding) and psychological (*e.g*., anxiety, sleep patterns) parameters in lactating women.

### Chinese medicine

In Chinese Medicine, Makhana is called Quin Shi. In traditional Chinese medicine, Makhana helps prevent kidney-related and other medical conditions like spermatorrhea, premature ejaculation, neuralgia, incontinence and chronic diarrhea. Makhana is also used for the treatment of conditions like arthritis, erectile dysfunction and premature aging. In Chinese Medicine, up to 30 grams of makhana per day is usually the recommended dosage (Masram *et al*., 2015).

## CONCLUSION

Makhana seeds have gained global recognition as a nutrient-dense superfood with remarkable therapeutic potential. These seeds offer a solution to micronutrient deficiencies, lifestyle diseases and the aging process, making them highly appealing to health-conscious consumers. Makhana is rich in bioactive compounds such as polyphenols, alkaloids, phenols, terpenoids and glycosides. It is an excellent source of macronutrients, micronutrients and phytochemicals while being low in sodium, saturated fats and cholesterol. Additionally, its high mineral and amino acid content further enhances its nutritional profile. The unique functional properties of makhana contribute to a wide range of health benefits, making it particularly suitable for individuals dealing with obesity, hypertension and cholesterol issues. In Indian cuisine, makhana-based recipes are not only valued for their nutrition but also hold religious and cultural significance.

Makhana's versatile qualities make it an ideal raw material for the development of innovative, healthy value-added food products. These products can improve the physicochemical, functional and sensory attributes of various food items. To promote societal health, there is a pressing need to scientifically innovate and adapt to regional nutritious cuisines, using makhana as a cornerstone ingredient.

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