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Cultivation of Makhana (*Euryale ferox*): An economic and Medicinal Crop for health and upliftment for poor inhabitants

Babita Kumari^{1*} and Hitesh Solanki²

¹Department of Environmental Science, CASAR, BEST Innovation University, Gorantla, Andhra Pradesh-515232

²Department of Botany, Gujarat University, Ahmadabad, Gujarat-380009

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Abstract: Fox nut (*Euryale ferox*), an aquatic crop of the Family Nymphaeaceae commonly known as MAKHANA, is unique, highly nutritious, non-cereal food cultivated in flood prone zone of north Bihar, lower Assam, and part of Bengal. It is commonly known as Makhana or Gorgon nut or Fox nut, and grown in stagnant perennial water bodies like ponds, land depressions, oxbow lakes, swamps and ditches. Makhana seeds are also called as Black Diamond. The seeds of Makhana are popped and eaten as roasted as well as used in preparation of various kind of sweets and recipes. It has nutritional and medicinal properties and there is a great export potential of this crop. Production of fox-nut in Bihar state accounts for over 80% of the Makhana production of the country. Darbhanga, Madhubani, Saharsa, Katihar, Purnea, Supaul, Kishanganj, Araria and Sitamari districts are major producer of Makhana (Figure A). These districts comprise an area of 15000 ha under makhana cultivation with an average productivity of 1.5 t/ha. The State Government has set a target to extend the cultivation of makhana in 20,000 ha by 2020, adopting the field based makhana cultivation technology. The nutritional analysis showed the highest content of carbohydrates in comparison to protein, mineral, fat and dietary fibres. However, the

individual analysis of mineral content shows excessive amount of Sodium in comparison to other minerals. Phosphorus is also seeming to be satisfactory content. The objective of this study was to review a short approach on economic, nutritional and medicinal aspects of Fox nut of India for human health perspectives

Keywords: Fox nut, Makhana, Makhana Cultivation, Nutritional component of Makhana

INTRODUCTION

Euryale ferox (common names prickly waterlily, foxnut, gorgon nut or makhana) is the only extant species in the genus *Euryale*. It is a flowering plant classified in the water lily family, Nymphaeaceae, although it is occasionally regarded as a distinct family, Euryalaceae (**Figure 1**). The nature of attributes summarized in Table 2. Most important features are high seedling vigour, large size flowers, days to 50% flowering 120-125 days, colour of petals are Bright Purple, fruit shape Spheroid, fruit colour is whitish brown, deep black seed coat colour, Seed shape is spherical, 100-seed weight is 28-30g, popped seeds (*Lawa*) shape is oblate and colour is sparkly white. The Makhana plant has rhizomatous stem. The rhizome is short thick and erect, leaf buds are folded up in involucre. Leaves are alternate, round, large (1-2m) and floating in nature. These are born on a 3-5 feet long petiole. The colour of upper surface appears to be green while the lower one looks deep purple. Both surfaces are covered by numerous thorns. The flowers are complete, big, solitary, bright purple in colour with long pedicel. The thalamus is fleshy and goblet-shaped. The number of sepals is four. They are persistent, green and thorny which gradually merge into the petals. The petals are of purple colour.

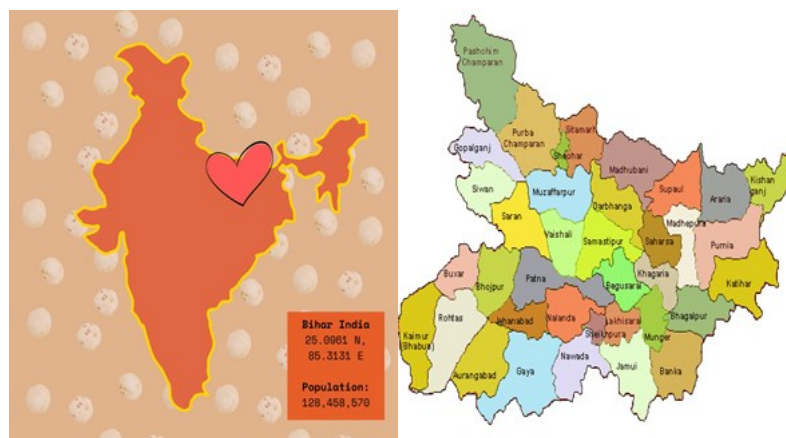


Figure 1: Map Showing the production of Makhana in Bihar

Taxonomy Classification

Kingdom:	Plantae
Genus:	<i>Euryale</i>
Species:	<i>E. ferox</i>
Family:	Nymphaeaceae
Scientific name:	Nymphaeales
Order:	Nymphaeales

MATERIALS AND METHODS

Makhana (Foxnut), also known as Gorgon Nut, is grown in India, Korea, Japan and Russia. Makhana has been proven to be high nutrients food which is rich in medicinal properties and good for daily health diet. The nutrients contained are vitamin, minerals and fibres. Makhana is a high value commodity commercially cultivated only in Bihar and certain parts of eastern India. and Manipur. The area under makhana cultivation in Bihar is about 13,000 ha ^[1]. Bihar produces about 90% of makhana of the country and according to an official figure, around 25,000 MT of makhana is produced every year in Bihar with an annual turnover of Rs.300 crores (The New Times Express,2020)

About five lakh families are directly involved in makhana cultivation, its harvesting, popping, and produce selling, etc. About 7500- 10,000 tons of popped makhana is sold every year in the market costing Rs. 200-500/kg, depending on availability, season etc ^[2]. Fox nut (*Euryale ferox* Salisb) is a plant of tropical and subtropical climate. For its proper growth and development, the conducive range of air temperature is 20 to 35°C, relative humidity 50%-90% and annual rainfall of 100-250 cm, organically reach water bodies with less than 50% water transparency. An important aquatic herb, prickly water plant with gigantic floating nature leaves of a size of 1-2 m, and these leaves are born on 3-5 feet long petioles, green in upper and purple in lower side, thorny in both side of leaf even in entire plant. It grows well in stagnant water of 0.2-2 m depth, with thick rhizomatous stem, deeply rooted in cluster form in sediment. Crop cultivation Fox nut is cultivated either in water bodies/ponds having water depth of 4-6 ft. or in 1-2 ft deep shallow agricultural fields.

Ponds system It is the traditional method of makhana cultivation. In water bodies, seed sowing is not required, since leftover seed of previous crop serves as planting materials of subsequent crops ^[3]. However, Makhana cultivation in new water bodies (ponds) requires seed sowing. The seeds should be broadcasted @ 80 kg/ha in the month of December. In general, pond cultivation is linked with low productivity as collection of seed from bottom is a very tedious process and possesses drudgery to health to Jalkar farmers. Under pond condition, it takes a duration of complete one year ^[4-6]. The importance of these findings has been discussed for national water resource economy of the country and human health perspectives ^[7].



Figure 2: Makhana Plant growing in a pond



Figure 3: A complete Plant of Fox nut



Figure 4: Raw Pops of Makhana



Figure 5: Roasted Pops of makhana

Cultivation of Makhana: First of all, ponds or swampy wastelands, field and take the seeds are sown from the seeds left from the previous harvest or the market or online websites [8]. The depth of the pond can be around 4-6 feet and must have stagnant water all times. Even the makhana seedlings can initially be prepared like other nursery plants and transplanted in the water field between February to April month. The complete cultivated and mature leaf of Makhana shown in Pond. Major work in makhana cultivation is the harvesting and it is not easy. It calls for the collection of seeds from the mud lying at the bottom of the pond and requires skilled laborer's [9] After that, the seeds are dried under full sun exposure to evaporating the moisture and it releases up to 31 per cent of the moisture.

Then the makhana can be temporarily stored for maximum 20-24 days. Then comes grading in which sun-dried seeds are divided from 5 -7 grades, based upon their size. Cultivators use a set of sieves for this purpose and further, it is followed by heating and roasting. In heating, the seeds are heated on an earthen or cast-iron pan at 250° C – 3000° C temperature and require continuous stirring and heating for 4-6 minutes. Then comes the storage as the heated seeds are stored at a dry place for 3-4 days. They naturally lose the inner edible part of makhana i.e. kernel from the outer hard shell. Finally roasting and polishing is done and the seeds are again heated in the pan at 2900° C-3400° C temperature. They are put in a single layer and continually stirred within around 2 minutes; the seeds start popping. Then, after putting on the ground, using a wooden hammer processor beats the seeds to separate and extract the kernel from the hard coating. The kernel or Makhana are rubbed against bamboo basket for imparting whiteness & crispiness. Then, further grading of makhana occurs according to the sizes and are packed into gunny bags for storing and transporting.

Types of Makhana and its medicinal impact: Generally, two types of dried lotus seeds can be found commercially; *brown peel* and *white*. The former is harvested when the seed head of the lotus is ripe or nearly ripe and the latter is harvested when the seed head is still fully green but with almost fully developed seeds. White lotus seeds are de-shelled and de-membrated.

At harvest, the bitter-tasting germ of most seeds is removed using a hollow needle. Brown peel lotus seeds are brown because the ripened seed has adhered to its membrane [10]. Lotus seeds are also common in the northern part of Colombia, especially in cities like Barranquilla and Cartagena. Locals usually refer to lotus seeds as "martillo." Fresh lotus seeds are sold in street markets and are generally eaten raw by the locals. Lotus seeds, known as Makhana, are used as food supplement for women after childbirth in Indian subcontinent. *Makhana*, as mentioned, are lotus seeds that are popularly used for medicinal purposes in Asia [11].

It is also used in various cuisines around the continent. Lotus seeds can be eaten both raw and cooked and they have a lot of nutritional value. *Makhana* seeds are great for treating insomnia. Insomnia may be caused due to a variety of reasons like changing patterns in hormones, stress and food habits. Diarrhoea is another problem that can be easily countered with the help of lotus seeds [12-13]. A lot of women face issues because of changes in hormonal balance. This includes diarrhoea as well, and lotus seeds are said to be a great remedy for the same Lotus seeds are perfect for regulating blood pressure. There is an embryo in the middle of the lotus seed, which has vitamins and provides a cooling effect on the body which improve blood flow and lower blood pressure. The bleeding gums due to pregnancy, can be solve by consuming makhana [14-16]. Makhana can be hard to control weight. It is important that you eat well, but at the same time, do not overeat. *Makhana* can also help in controlling the sugar levels in your blood during pregnancy [17-18].

Preparation of makhana flour: A couple of Fresh makhana seeds were cleaned in fresh water and air dried at shade. The seed dried with the help of hot blower. After drying, the crushing of seed done to remove seed coat and separated the kernels. After separation from the husk, kernels were smashed to

get seed coat free from fine white flour. In 10 ml distilled water 1 gm of flour was taken mixed and kept in ambient temperature (32.0 °C) for ½ hr and centrifuged 30 min at 3000 rpm.

Biochemical content:

- **Carbohydrate content:** Makhana is excellent source of quality carbohydrate. Phytochemical analysis was also done with respect to total carbohydrate (% by wt) ^[19].
- **Mineral Content:** For determining mineral content, seed kernel (whole) were washed initially by tap water followed by dilute hydrochloric acid (0.05 N) and finally with double distilled water. The kernel samples were then dried in air oven at a temperature of 65 ± 5°C for 24 hours ground and passed through an 80-mesh sieve (180 µm). Mineral was measured with an atomic absorption spectrophotometer (Analyst 100, PerkinElmer, and Norwalk, CT, USA) ^[19].
- **Protein Content:** Makhana contains high quality easily digestible protein. The crude protein content of the seeds varies widely depending on many factors, was obtained by makhana ^[19].
- **Fat content:** Makhana contains least fat and is good for the health point of view. Seed were also analyzed for fat estimation ^[19].
- **Water content:** Moisture content was determined and expressed in per cent (% by wt) ^[16].
- **Fibre content:** Total dietary fiber was estimated by enzymatic-gravimetric method as per AOAC Official Method 985.29. Total dietary fiber assay kit (K-TDFR) and total dietary fiber control kit (KTDFC) was obtained from Megazyme, Ireland were used in analysis ^[20]

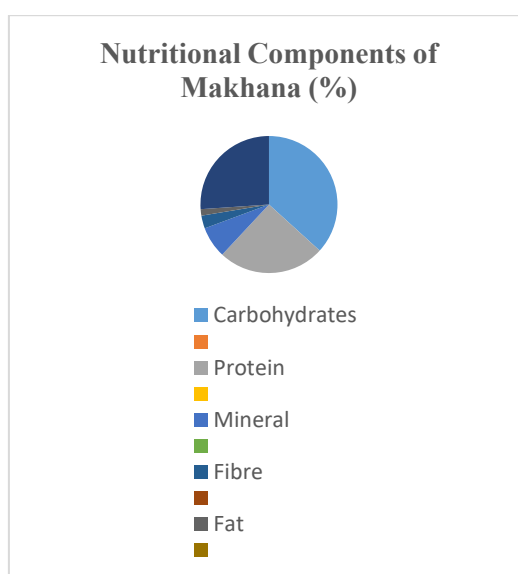


Figure 6: Nutritional Composition of Makhana

RESULT AND DISCUSSION

Makhana has shown a significant nutritional concept for body building activities. Its seeds have plenty of nutritional value attached to them. It is considered one of the healthiest foods for a mother to consume during pregnancy and it is extracted from the lotus flower ^[21,22]. Makhana are rich in nutrients and are a highly potent source of manganese, potassium, magnesium, thiamine, protein, and phosphorus. Most of the researcher revealed that Makhana contains high quality easily digestible protein. The present

study shown the total contents of minerals in Figure C. The figure shows highest amount of sodium and phosphorus in makhana comparison to other mineral content like zinc, manganese, magnesium etc. As we know that phosphorus builds a good remark to strengthening the bones and teeth parts. In lieu of this, it has also a good bioaccumulation property for heavy metals reported by many scientists in aquatic phenomenon. In most of the studies, some environmental disturbances like eutrophication by weeds in Kosi region fluctuate the yield of makhana. This is also causing troublesome to makhana cultivators of Kosiregion. Shanker *et al.*^[23] also reported this problem facing by the makhana cultivators of Darbhanga.

Availability of short period of lease in Govt. or private ponds or lands and growing of same species or variety of makhana seeds by the cultivators as makhana is a monotypic genus, were also seen in North-Eastern region of Bihar. Left out makhana seeds germinate in the next season. ICAR developed improved variety of makhana, Swarna Vaidehi^[24] is out of reach of the makhana cultivators and it is the major drawback in productivity of makhana.

The comparative nutritional and minerals analysis was shown to have a marginal fluctuation as done by present study. A couple of scientists proved that popped and raw seeds of newly developed “swarna vaidehi” variety of Makhana has been evaluated for its nutritional quality along with local check. Maximum crude fiber (0.5%) was obtained in the raw seeds of swarna vaidehi as compare to popped one. Maximum calorific value (358) was recorded in popped seeds of swarna vaidehi. The crude protein content of the seeds varies widely depending on many factors, for example variety, fertilizer application, and location of growth. (Table 1 & 2).

The protein is the good source found in makhana having significant ability to empower immunity. The seed coat contains less protein and more carbohydrate in comparison to cotyledons and whole seeds^[26] The dried lotus seeds supply 332 calories and contain 85% carbohydrates, 2% fat, 15% protein, and 14% water similar to present study^[15,27,28]. In case of mineral composition, maximum (79.1mg) phosphorus was recorded in case of popped seeds of local check cultivar, similarly in case of potassium maximum (56.0 mg) was recorded with popped seeds of local check cultivar.

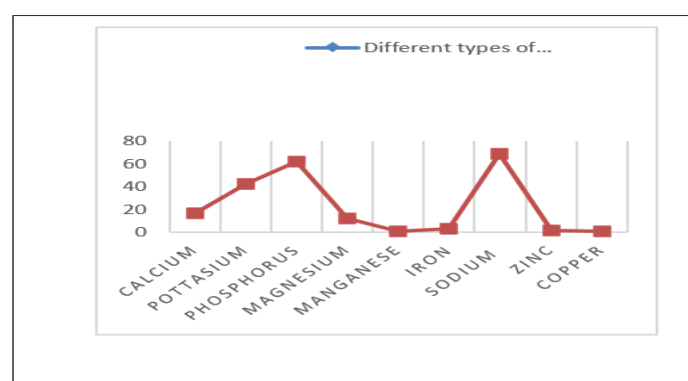
Table 1: Comparative study of nutritional profile of Swarna Vaidehi variety of and local cultivar of Makhana^[25].

Parameters	Popped seeds of Swarna Vaidehi	Popped seeds of Local check	Raw Seeds of Swarna Vaidehi
Moisture (% by wt.)	10.4	11.1	34.7
Total ash (% by wt.)	0.4	0.4	0.3
Fat (% by wt.)	0.5	0.2	0.3
Protein (% by wt.) (N x 6.25)	8.7	8.6	7.2
Crude fiber (% by wt.)	0.2	0.3	0.5
Carbohydrate (% by wt.)	79.8	79.4	57.0
Amylose %	18.2	18.5	19.0
Calorific value (K. cal/100g)	358	354	259

Table 2: The data of mineral composition of Swarna Vaidehi variety of and local cultivar of Makhana ^[25]

Parameters	Popped seeds of Swarna Vaidehi	Popped seeds of Local check	Raw Seeds of Swarna Vaidehi
Phosphorus (mg/100g)	53.2	79.1	66.1
Potassium (mg/100g)	42.0	56.0	35.6
Iron (mg/100g)	1.4	1.9	0.8
Calcium (mg/100g)	18.5	13.0	9.5
Magnesium (mg/100g)	13.9	11.9	11.3
Sodium (mg/100g)	71.0	65.2	48.2
Copper (mg/100g)	0.5	0.4	0.3
Manganese (mg/100g)	1.3	1.3	0.9
Zinc (mg/100g)	1.1	0.7	0.9

Maximum (1.9 mg) iron content was recorded in case of popped seeds of local cultivar. Maximum (18.5mg) calcium content was recorded in case of popped seeds of swarna vaidehi. It was worth to mention that maximum (1.1) zinc content was recorded in case of popped seeds of swarna vaidehi. Thus, the overall study shown a good impact of nutritional, mineral and the medicinal impact of makhana on health concept.

**Figure 7:** Different Contents of Minerals in Makhana.

CONCLUSION

From the present study, we concluded that makhana seed has been evaluated for its nutritional quality. Maximum carbohydrate content (85%) was recorded in tested sample. The amount of protein obtained is proof to be a significant impact for immunity wise health concern. In case of mineral composition, the highest content of sodium followed by phosphorus was recorded. On the other hand, fibres are seeming to recorded in rare amount. Thus, makhana proved to be a very

good nutritional candidate for health concern. The use of seed for bioaccumulation of heavy metal was also highlighted by several scientist is discussed in this paper. It needs some more research to stimulated the health benefits of makhana in worldwide concern for every category of peoples.

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***Corresponding Author: Babita Kumari,**

Department of Environmental Science, CASAR, BEST Innovation University,
Gorantla, Andhra Pradesh-515232

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