

Makhana in Nutritional, Medicinal and Socio - Cultural Uses in the Koshi - Mithila Region of Bihar

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Abstract

Original Research Article

Makhana (*Euryale ferox* Salisb.) is an aquatic cash crop of Bihar known for its nutritional and medicinal properties with immense potential since long time. It is mainly cultivated for its edible seeds and tasty snacks. In India, Bihar state alone accounts for more than 85% of the makhana production. Approximately 80% of the total productions of processed makhana in Bihar come from Northern Bihar consisting of Darbhanga, Madhubani, Katihar, Purnea, Sitamarhi, Saharsa, Supaul, Araria and Kishanganj districts popularly called Koshi - Mithila region. Makhana is deeply associated with the nutritional, medicinal, social, cultural, ceremonial and religious uses amongst the people Koshi - Mithila region. In this region makhana pops are found to be used variously as roasted makhana snack especially in the evening, in the preparation of a number of delicious and rich dishes, as a non-cereal food by Hindu devotees during fasts and breaking *roja* (fasting) during *Ramjaan Sharif* by Muslim communities. Due to its heavenly nature it is also considered as the best offering to Gods and Goddesses in the temples. It is also used in the marriage ceremonies in most of the communities of Koshi - Mithila region. People often use makhana pops for garlands and decorative purposes especially during ceremonial and political welcomes. Makhana pops are fairly rich in essential amino acids and are the store house of several essential macro and minor nutrients. Makhana is considered to be superior to other dry fruits like almond, walnut, cashew nut and coconut in contents of sugar, proteins, ascorbic acid and phenol. On account of being fatless, aphrodisiac, spermatogenic, light, digestive, antispasmodic and high contents of carbohydrates, proteins and minerals makhana pops are in high demand in western and gulf countries. It is one of the common dry fruits usually relished by the affluent people of the northern Bihar, India and abroad too due to its nutritional and medicinal values. Due to their powerful medicinal properties makhana pops are used against a number of human ailments involving respiratory, circulatory, digestive, excretory and reproductive systems as recommended by the Indian and Chinese system of medicines. According to Ayurveda makhana alleviates *vata*, *pitta* and *cough* dosha. Recently, it has been found that there is an increasing trend of consuming makhana pops for the treatment of diabetes and obesity in this region.

Key words: Makhana, superior dry fruit, nutritional value, medicinal uses, socio-ceremonial functions, religious purposes.

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INTRODUCTION

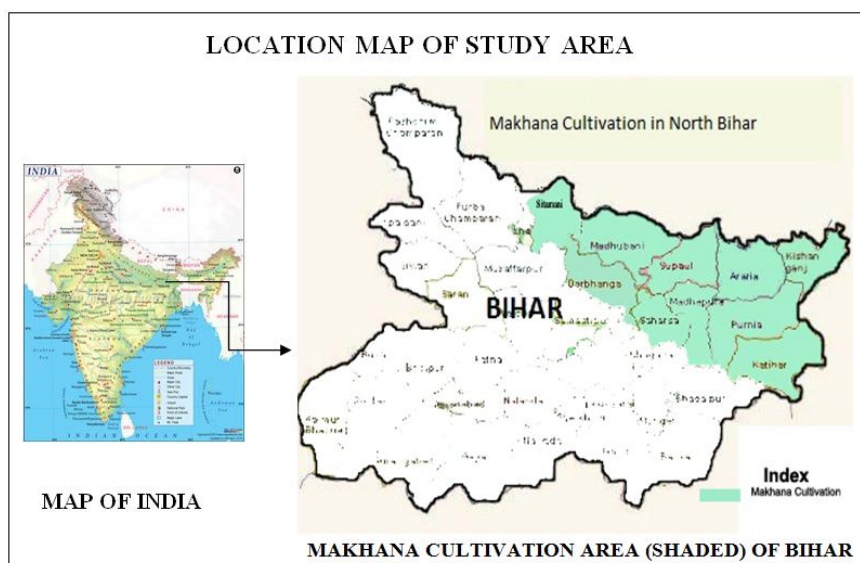
Euryale ferox Salisb. Commonly known as fox nut, gorgon nut, prickly water lily or makhana is the only species of the genus [1]. It is aquaphytes distributed in the tropical and subtropical regions of South-east and East Asia [2]. It is well adapted to the shallow water bodies in natural wild forms in various parts of north-east India (Assam, Meghalaya and Orissa) and scattered pockets of central and northern India (as Gorakhpur and Alwar). However, Koshi and Mithila regions of North Bihar are the principal areas of its present existence cultivated mainly for its nutritious edible seeds and tasty snacks which look like popcorn. The plant is a stem less prickly aquatic herb with short

and thick root stock [3]. The leaves are submerged, oblong, orbicular, corrugated about 6-100 cm in diameter, reddish green above, purple below and densely spiny [4]. Most flowers are cleistogamous but chasmogamous flowers may also be produced. The flowers are solitary, submerged and epigynous with four persistent, thorny sepals inserted on the torus above the level of the ovary together with many seriate petals. The inferior multicarpellary ovary develops into a spongy berry like fruit which is densely prickly, the size of an orange and contains 30-40 pea size seeds with hard black seed coat and a mucilaginous aril. The pulpy aril keeps the seed floating for a few days after they dehisce, before they finally settle down to the bottom water.

Makhana seeds are also called as black diamond [5] of wetlands. Bihar is the largest producer of makhana (20000 MT) in India accounting about 85% of total makhana produced in the country [6, 7]. Approximately 80% of total production of processed makhana in Bihar comes from North Bihar [8]. In Bihar Madhubani, Darbhanga, district occupies the highest share in total production of makhana pop which contributes about 20% of total production in State i.e. 3000 MT followed by Katihar 18%, Purnea 15% and Darbhanga 14% and rest other districts [9]. Katihar district is fast emerging as an important hub for cultivation and trading of makhana [10]. This district is known to produce good quality of makhana seeds and the seeds of this district have the maximum seed sprouting capacity [7,11]. Makhana primarily serve the purpose of being consumed as a food item for local and religious purposes. It provides livelihood to the fisherman and other related communities. The present work aims to review and give more information about nutritional values and medicinal, social, ceremonial and religious uses of makhana done by the people of Koshi - Mithila region of Bihar.

MATERIALS AND METHODS

A detailed survey was made to know the various nutritional, medicinal, social, ceremonial, cultural and religious uses of makhana in Koshi - Mithila region consisting of Katihar, Araria, Purnea, Kishanganj, Madhepura, Supaul, Saharsa, Madhubani, Darbhanga and Sitamarhi districts of Bihar (Location Map). The field data on various medicinal, socio-cultural and religious uses of makhana was collected during the period of July 2014-16. Field trips were organized to various villages and cities of Katihar, Supaul, Madhubani and other districts of Koshi-Mithila region. The field work consisted of data documentation and photography. A combination of individual interviews of focus group, field work discussions and local market survey was conducted. The information was collected after discussion with local people. The selection of informants (local vaidyas) was mainly based on their rich indigenous knowledge and long term experience of utilization of plants. The informants were asked various questions about their traditional knowledge of makhana used in the disease treatment as well as socio-cultural and religious uses. The chemical constituents of makhana seed pops were also analysed. The compiled information was reviewed with the chemical composition, nutritional values and medicinal properties of makhana as per pharmacology (Dravyayuna), magazines and research journals as well as PUBMED and MEDLINE data bases.



RESULTS AND DISCUSSION

Nutritional Values

Cultivation of makhana is a very complicated, cumbersome and pains taking process (Plate 1). It requires skilled labours to produce makhana. However, nutritionally makhana seed pops are very rich. Makhana seeds are high in magnesium, potassium and phosphorus and very low in saturated fats, cholesterol and sodium [8]. Nutritional studies (Table 1) reflect that weight by

weight the popped fox nut (perisperm) contains 11.92% moisture, 75.94% carbohydrate, 9.8% easily digestible protein, 0.2% fat, 2.32% crude fibre and 3.36% ash. The results are almost comparable to the findings of Nath *et al.* [12], Kumar *et al.* [13] and Kumar *et al.* [14]. Nath *et al.* also detected 0.02% calcium, 0.9% phosphorus and 0.0014% iron in makhana pops whereas Kumar *et al.* recorded 0.0532% phosphorus, 0.0014% iron with 358 calorific value (K. cal. /100 g) in makhana pops. Makhana protein despite of its low percentage content (10-12%) relative to most cereals is nutritionally

superior to several plants and animal based diets and easily digestible to all groups.

Makhana (*Euryale ferox* Salisb.) because of having low fat content and high contents of carbohydrate, protein and minerals it is used as ideal food during the fasting of *Navratri* by Hindus to control appetite and get energy [13]. In makhana besides a good proposition of sugar, phenol and ascorbic acid, its amino acid index is higher than those of staple foods which signify its unique food quality [15].

Makhana pops contain higher content of arginine, alanine and tyrosine amino acids in protein (g/16g) as compared to egg and FAO/WHO pattern (Table 2). Loss in the amount of tyrosine is remarkable during the popping of makhana while the values of lysine, arginine, threonine, serine, glutamic acid, glycine, alanine, valine, cystine, isoleucine, leucine and phenylalanine are higher [16]. Because of its lower biological value (BV) makhana can be recommended as a complementary food item along with the staple ones. The comparative values of Essential Amino Acid Index (EAAI) and Biological Value (BV) of foods are depicted in Table 3. NPU (Net Protein Utilization), AD (Apparent Digestibility) and TD (True Digestibility) values of makhana are comparable to the values cereals [17] and quite low to those of soybean, egg and human and cow milk [FAO/WHO 1973]. As makhana seeds are rich in essential amino acids so the values relating to essential amino acid index (EAAI) and chemical score (CS) of makhana are close to that of fish, mutton and milk [17]. The higher essential amino acid value is found in raw makhana (93.63%) and popped makhana (89.95%) as compared to the value of plant-based diets *viz.* rice (83%), wheat (65%), bengal gram (81.5%), cow's milk (88.8%), fish (89.2%) and mutton (87.24%) [18-20]. Makhana protein (10-12%) is a bit lower when compared to cereals. The biological value (BV) of plant and animal-based diets is usually higher (50.7 - 84.5%) to puffed makhana seeds which is found to be 55%. The ratio of protein utilization for growth rate is explained by Arginine + Lysine upon Proline ratio [(A+L)/P] in foods (Table 4) which is 6.3 in raw and 4.74 in the popped makhana seeds [21]. Nath and Chakroborty reported the higher value (7.6) of A+L/P in wild population of makhana from Tripura [12]. Makhana seeds are rich in gluten free protein (gluten is a protein found in wheat, barley and rye) and avoid immune reaction to eating gluten. The trace metals like Cu, Na, Ca, Fe and Mg have been detected in the seed-meal and whole starch of makhana which shows a declining trend on purifying starch (Table 5). The reduction is more pronounced in case of Ca and Mg [22]. Makhana is found to be superior to dry fruits such as almond, walnut, cashew nut and coconut in contents of sugar, proteins, ascorbic acid and phenol [23].

Medicinal Uses

Makhana has powerful medicinal properties against a number of human ailments involving the respiratory, circulatory, digestive, excretory and reproductive systems as recommended in the Indian and Chinese system of medicine (Fig. 1). All parts of plant have tonic, astringent and non-obstructing properties as shown in old literature [24]. In Koshi- Mithila region makhana seed pops are recommended for the treatment of polyuria, spermatorrhoea, gonorrhoea, diarrhoea, stomachache, body ache, loss of appetite, weakness during and after pregnancy, general debility, sexual dysfunctions like impotence, premature ejaculation and nocturnal emissions, sexual disinterest, vaginal discharges (leucorrhoea), numbness, depression, weight loss, joints pain, diabetes, high BP, insomnia and beri-beri by the local vaidyas [8, 25].

The low cholesterol, low sodium, gluten free protein and high K, Mg and fiber content make makhana seed pops extremely useful ideal food for those suffering from heart diseases, high blood pressure, diabetes, kidney diseases and obesity. High Mg content of makhana keeps the arteries clean and regulates blood flow. Since makhana seeds are high in fibre, it also helps to avoid constipation. Its antiaging enzymes and *kaempferol* flavonoid in seeds help in repairing damaged proteins and preventing inflammation in the body. It is easily digestible to all groups from children to old ones. Its astringent property benefits kidney therefore good for people suffering from urine infections. It detoxifies body cells and spleen and prevents the formation of kidney stones. High content of Ca in makhana seeds is helpful in body pains and arthritis. Various workers have also reported the use of makhana pops in the treatment of different diseases. J. Roi 1945 [26, 27] have reported the seeds of makhana to be very effective in the treatment of stomach disease, articular pains, micturition and seminal loss. The decoction of the seed is roborant as it increases secretions of hormones [28]. Crevost and Petelot 1929 [29] and Liu 1952 [30] reported that the seeds were used as tonic of seminal-orgasm. The farinaceous seeds have binding action in dysentery but when taken in over dose it causes constipation and flatulence. Its effectiveness against digestive disorders and weight loss is mainly due to antioxidant property, high content of dietary fibers, low cholesterol and very small sized (1-3 μ m) starch granules [31]. Seeds are also used against *dysmenorrhoea* in the Unani system [32]. High amount of vitamins present in seeds is very effective against the disease *beriberi* caused by the deficiency of Vitamin B [33].

Ayurveda, the conventional system of Indian medicine holds makhana to be beneficial in *Tridosas* (the Ayurvedic theory of diagnosing diseases on the basis of three principal defects of the body, especially *vata* and *pitta*, rheumatic and bile disorder respectively). The Central Drug Research Institute, Lucknow has divulged the presence of immunoral principles in its edible seeds.

Dictionary of Chinese Medicines reports its effectiveness in curing pyodermas, hernia and leucorrhoea [34]. Sokolov 1952 [35] reported the presence of a sesquiterpene alkaloid called *drummine* in the leaves of makhana which was found to be more effective against rheumatism. In China leaf ash of makhana cooked with fermented rice (laut-sao) is used to induce labour [36].

In the Chinese medicinal formula Chien-Shih, makhana is included as Su-Shin (a tonic) especially required for the growth of children [37]. It also acts as an emetic and expectorant [38]. Its medicinal impacts are also noted in treating circulatory disorders including haematemesis, haemoptysis, metrorrhagia, melaena, sprue and malabsorption syndromes [39].

Dietary Uses

Makhana pops are the powerhouse of nutrition and can prevent several diseases. It primarily serves the purpose of being consumed as a food item for local and religious purposes. It is also known for their antiaging, antioxidant, antiwrinkle, antispasmodic, antiallergic, antidiabetic, anti-inflammatory, analgesic, cardiac friendly, vitality, aphrodisiac and umpteen health benefits hence considered as the *super food*. Affluent people of this region include this miraculous ingredient in their daily diet and reap health. They are also the favourite snacks of cine stars and big politicians as they are helpful in reducing weight. They are high in demand amongst diabetic and overweight / obese patients also due to their low glycemic index and very low fat. Makhana pops are high in carbohydrates, loaded with several micronutrients and low in fat which are vital for proper functioning of the human body. This makes the makhana pops perfect munchy healthy snack in Indian cuisines. In Koshi - Mithila and Gangetic region it is variously used as kheer makhana, popular evening nutritious fried snacks (like *plain salted makhana*, *coconut makhana*, *pudina makhana*, *khatta meetha makhana*, *makhana namkeen*, *makhana chat*, *makhana maggi masala* etc.), dal makhani, vegetable curry, sweets etc (Fig 3). Makhana kheer or pudding is one of the important and favourite recipes in every Hindu household of this region due to its unique taste and health benefits [40, 41]. Makhana is a non-cereal food hence; it is the best loved dish during religious fasting festivals like *Navratri*, *Ganesh Chaturthi* etc [42]. This is also served on the different occasions like potlucks and titty parties or get - together parties. Some tasty sweets like *makhana coconut laddoo* and *makhana chikki* are also prepared with makhana in this region. Makhana is also added with paneer and *cream mushroom paneer* is also made with it. Makhana seed powder is also used as

substitute of arrowroot and is also used for making taste and thickening. Makhana powder is also used to make *stuffed puri* which is quite famous in Mithila region. It is also used as *baby food* because of its digestive and nutritive properties [37]. Salted and sweetened snacks also go well with tea. *Makhana rayata* is a delicacy served during marriage ceremonies and other occasions in the Koshi- Mithila region.

Social and Cultural Uses

Paan (betel), maach (fishes) and makhana (makhana) are the cultural identity of Koshi – Mithila region [40]. Makhana has been an integral part of culture and festivities of this region since along time. Along with medicinal and nutritional values it has several socio-ceremonial and cultural uses in this region (Fig. 4). It is considered as non-cereal ideal staple food for devotees in every religion as it is pious and divine food item of earth. Due to its heavenly nature, it is used in all the worshiping ceremonies like *hawan*, *poojas* etc. and considered as the best offering to Gods and Goddesses in the temples and religious rituals. In Mithila region it is also used as a gift at the time of marriage ceremonies and *gauna* ritual (when bride leaves her parents' house after marriage in Koshi - Mithila region). *Kojagara puja* is a very popular public festival of Koshi - Mithila region dedicated to Goddess *Lakshmi* and celebrated during the night of 'Ashwin Purnima' (full moon day). Makhana pops are essentially offered to the Goddess Lakshmi. This festival also marks the beginning of the married life of newly wedded couple hence, celebrated during the first year of the marriage. During *kojagara* makhana pops are essentially and generously gifted as omen by the parents of bride to bridegroom's family, their relatives and friends [43]. Muslim communities also use makhana for breaking *roza* during the period of *Ramjan*. Sikh communities also use it in *s* and *tilak* ceremonies along with other dry fruits. *Chhath* is the most important festivals of Bihar and makhana pops are one of the essential components of this festival which is offered to the God **Sun**. Makhana is also used for decorative purposes during pujas and ceremonies in Mithila region. Makhana powder is also used as a starch for fabrics. Makhana garlands are very popular in this region and used in garlanding big political leaders and other dignitaries as a mark of respects (Plate 2). Very recently MP of Supaul Mrs. Ranjeet Ranjan has also welcomed the Chairman of Indian National Congress Mr. Rahul Gandhi at Gandhi Maidan Supaul, Bihar by garlanding him with makhana garland on 20th April 2019 [44]. It is also used variously during death procession and in *shradha karma* / *karma kanda* of Hindus. As it is non-cereal food it is used as food supplement during fast.

Table-1: Chemical Constituents of Makana Pops (w/w)

Constituents	Authors self	Nath <i>et al.</i> 1985[12]	Kumar <i>et al.</i> 2011[14]	Kumar <i>et al.</i> 2017[17]
1. Moisture	11.92%	12.8%	12.8%	9.94-11.75%
2. Carbohydrate	75.26%	76.9%		70.84-73.48%
3. Protein	10.48%	9.7%	9.7	10.24-11.12%
4. Fat	0.2%	0.1	0.4	0.392-0.418%
5. Crude fibre	2.32%	-	0.2	2.46-2.54%
6. Ash	3.36%	-	-	3.394-3.424%
7. Total minerals	n.d.	0.5	-	-
8. Calcium (Ca)	n.d.	0.02	-	-
9. Phosphorus (P)	n.d.	0.9	-	-
10. Iron (Fe)	n.d.	0.0014	-	-
11. Calorific value (K. Cals./100g)	n.d.	n.d.	358	n.d.

Table-2: Protein and Amino Acid Composition (g/16gN) of Makhana and Egg and FAO/WHO Pattern

Amino acid	Makhana		Egg	FAO/WHO (1973)
	Raw	Fried		
Lysine	3.79	4.69	6.7	5.4
Histidine	3.15	3.12	3.5	2.5
Arginine	15.19	16.07	6.7	5.2
Aspartic acid	5.76	5.05	10.40	7.7
Threonine	3.34	3.51	5.1	4.0
Serine	5.05	5.64	6	7.7
Glutamic acid	16.64	17.06	25.20	14.7
Proline	4.00	3.24	-	10.7
Glycine	3.01	3.28	3.6	2.2
Alanine	5.50	5.84	3.5	6.1
Valine	5.18	5.49	7.5	5.0
Cystine	0.75	1.21	3.0	-
Methionine	3.06	2.95	2.3	3.5
Isoleucine	4.18	4.8	5.8	4.0
Leucine	8.34	8.85	8.9	7.0
Tyrosine	6.38	2.91	3.6	3.05
Phenylalanine	5.78	6.12	6.7	3.05
Tryptophan	n.d.	n.d.	1.5	1.00
Ammonia	0.9	1.16	-	-
Protien (%)	11.1	11.5	-	-

Source1: Jha *et al.* (1991) , n.d. = not determined.

Table-3: Comparative Value of Essential Amino Acid Index (EAAI) and Biological Value (BV) of foods

Feeds	EAAI	BV	CS (% EGG)	References
Edible items				
Rice	82.88	68	54.93	Gopalan <i>et al.</i> , 1985
Wheat	65.18	62.6	39.7	Eggum and Duggal, 1977

Bengal gram	81.55	68	53.33	Gopalan <i>et al.</i> , 1985
Soyabean	85.59	50.7	52.6	Sikka <i>et al.</i> , 1978
Amaranth	57.72	-	40.93	Gopalan <i>et al.</i> , 1985
Human Milk	81.55	-	59.7	Gopalan <i>et al.</i> , 1985
Cow's Milk	88.8	84.5*	52.54	Gopalan <i>et al.</i> , 1985 *Anon., 1970
Fish	89.2	59.7	65.7	Sikka <i>et al.</i> , 1979
Mutton	87.24	74	71.46	Gopalan <i>et al.</i> , 1985
Makhana				
Fried Makhana	89.97	55	56.57	Jha <i>et al.</i> , 1991
Raw Makhana	93.63	-	70	Jha <i>et al.</i> , 1991

Source : Jha et al., 1991

Table-4: Comparative Value of Leucine to Isoleucine and Arginine + Lysine to Proline Ratios in Foods

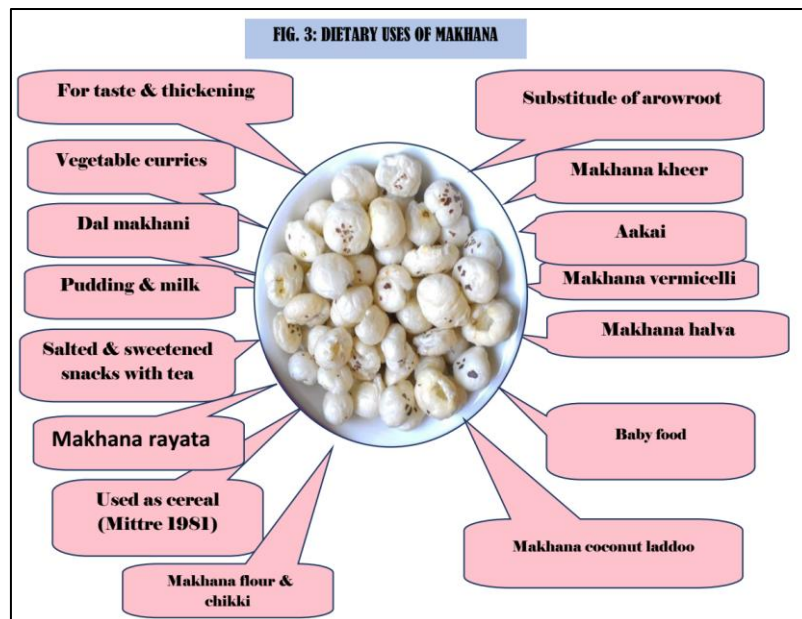
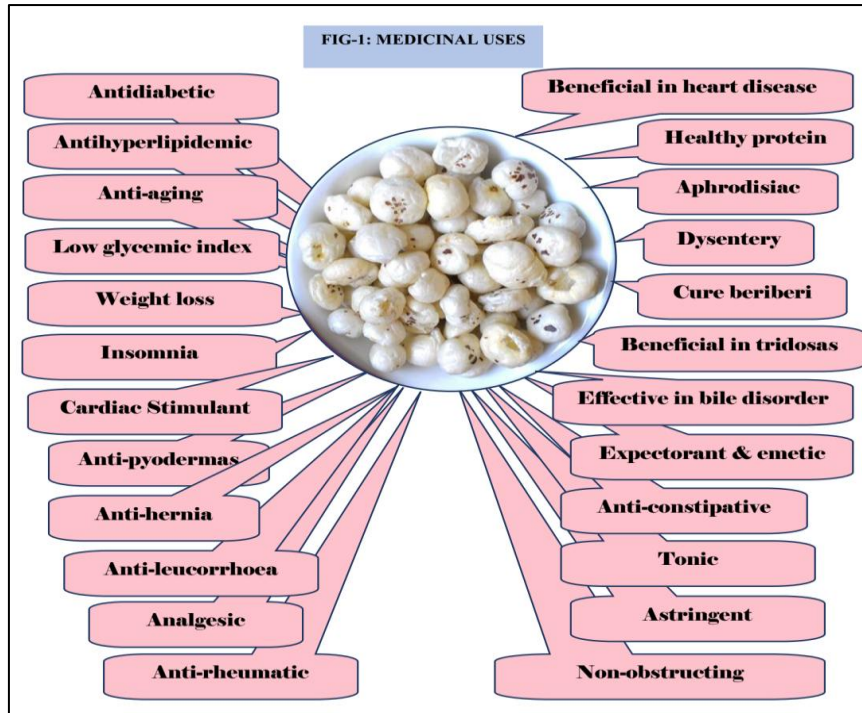
Feeds	Leucine/ Isoleucine	(Arginine+Lysine /Proline)	References
FAO/WHO pattern	1.75	0.99	Anon., 1973
Rice	1.66	4.00*	Gopalan <i>et al.</i> , 1985, *Anon., 1977
Wheat	1.66	0.71	Eggum & Duggal, 1977
Soybean	1.45	2.86	Sikka <i>et al.</i> , 1978
Amaranth	1.27	3.41	Gopalan <i>et al.</i> , 1985, *Anon., 1977
Human milk	-	1.58	Gopalan <i>et al.</i> , 1985
Cow's milk	1.76	-	Gopalan <i>et al.</i> , 1985
Fish	1.71	5.18	Sikka <i>et al.</i> , 1979
Mutton makhana	1.56	-	Gopalan <i>et al.</i> , 1985
Raw (Tripura ample)	1.9	7.6	Nath and Chakraborty, 1985 b
Raw (Bihar sample)	1.84	6.3	Jha <i>et al.</i> , 1991 a
Fried (Bihar sample)	1.99	4.74	Jha <i>et al.</i> , 1991 a

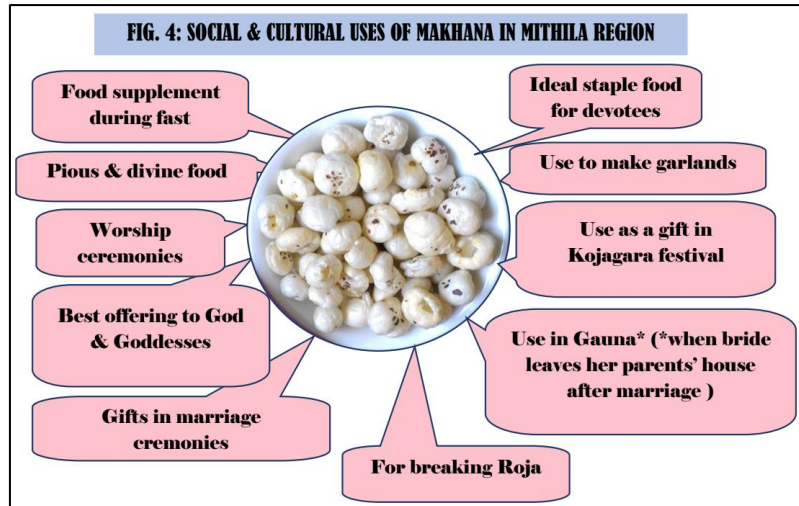
Source : Jha *et al.*, (1991)

Table-5: Detection of Trace Metals Present in the Starch of *Euryale ferox*

Sample	Cu (ppm)	Na (ppm)	Ca (ppm)	Fe (ppm)	Mg (ppm)
Seed meal	<1	1000	>1000	100	>2000
Whole starch	1	1000	>1000	100	>2000
Purified starch	<1	800	<200	80	100

Source : Nath and Chakraborty (1985a)





Plates-1: Morphology, harvesting & processing of makhana in koshi -mithila region of bihar



Makhana plants in a pond



Harvesting of makhana seeds



Flowers and fruits of makhana



Collection of makhana seeds



Makhana seeds ready for sale



Cracking of roasted seeds



Roasting of makhana seeds



Grading of makhana pops

Plates-2: Socio-cultural and dietary uses of makhana m in koshi region of bihar



Mrs. Ranjeet Ranjan (MP) garlanding Congress Chairman Mr. Rahul Gandhi with makhana garland



Makhana used by Sikhs in marriage ceermoney



Makhana used during Roza



Makhana Curry



Makhana used for worshipping by Hindus



Dal Makhana



Makhana snacks



Makhana Kheer

CONCLUSION

Makhana is an integral part of culture of Koshi-Mithila region of Bihar. In every religious and matrimonial ceremony makhana occupies an important position in this region. Makhana seed pops popularly known as the *makhana lava* have tremendous nutritional, medicinal and health benefits as also supported by Indian Ayurvedic and Chinese medicine systems. They are in high demand in foreign countries due to low fat, low calorie, rich nutrients, high carbohydrate, high fibre, gluten free proteins, aphrodisiac nature, heart friendly, antiobese, anticonstipative and antidiabetic properties. Hence it has an important source of earning foreign currency for India. India earns about 22 to 25 crores of rupees every year by exporting makhana [45]. Bihar caters more than 85% of makhana production in India of which 80% share is of Koshi-Mithila region. There is a tremendous scope of increasing makhana cultivation in this flood prone region. This will increase the local economy and exports of makhana to different foreign countries from this region. Recently a young and progressive businessman of Singapore Vauter Duke have shown interest in exporting makhana snacks from Koshi - Seemanchal region to Australia, Korea, Japan, Singapore and other Asian Pacific countries as makhana is not produced in Asian countries [46]. Hence there is a large scope of export of makhana and earning foreign currency. Makhana is an underutilized and underinvestigated non - cereal aquatic crop. Considering its immense health benefits and medicinal properties there is a need of proper marketing to popularize this divine crop also. However, an excessive consumption of makhana may lead to side effects for some people so it should be consumed in moderation. Allergies, gastrointestinal issues, spike, flatulence, bloating and constipation are some of the side effects of makhana (Fig. 2) when taken in excessive amount [47]. Makhana tends to bring down blood sugar levels if people suffering from diabetes consume it in excess. If any person is already constipated he/she should discontinue its usage. Makhana bran which is considered as a waste material can be used in poultry feed.

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