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A comprehensive review on health benefits and nutritional aspects of Foxnut (Makhana)

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Abstract

This article shows the importance of makhana, nutritional aspects of makhana the makhana is rich in with minerals, protein, and carbohydrates. It has 12.8% in it. 76.9% of it is water, 9.7% is protein, and 0.1% is fat, 0.02% calcium, 0.9% phosphorus, and 0.5% total minerals and 0.004%. foxnut had a good therapeutic potential also it contains many antioxidant compounds that responsible antioxidant for better antioxidant property. Foxnut been used as a traditional medicine. The value-added products of makhana includes makhana burfi, makhana powder mix, makhana kalakand, makhana pakora and makhana chapati etc. The future of makhana is increasing day by day. Makhana has a high nutritional content and several health advantages, thus demand has been steadily rising recently. The modern makhana in India is devoured all across the nation.

Keywords: Euryale ferox salisb, makhana powder, makhana pakora, makhana kalakand, burfi

1. Introduction

Aquatic crop *Euryale ferox salisb.*, sometimes referred to as "makhana," is a member of the Nymphaeaceae family. It is mostly sold in nations in South and East Asia, including India, China, Nepal, Bangladesh, Japan, Russia, Korea, and others. Its cultivation in India is restricted to a few states, including Bihar, Assam, Manipur, and West Odisha, Tripura, and Bengal. (Pratap, 2021) [8]. The edible portion of the plant that is consumed in the shape of small, rounded makhana seeds with an outer covering that ranges in color from black to brown of processed lava that has burst. A popped makhana a very good source of food that is incredibly nourishing with minerals, protein, and carbohydrates. It has 12.8% in it. 76.9% of it is water, 9.7% is protein, and 0.1% is fat, 0.02% calcium, 0.9% phosphorus, and 0.5% total minerals and 0.004% iron (Singh *et al.*, 2020) [9]. Approximately 80% of the whole production of processed Makhana is produced in just the districts of Darbhanga, Madhubani, Purnia, and Katihar. The area used for makhana farming is roughly 13,000 hectares Makhana farming is a source of income for Numerous farmers have limited resources, particularly in Bihar and Manipur. Dry fruits are marketed in the form of a cash crop of pop makhana, sometimes referred to as Makhana-lawa (Kumar *et al.*, 2016) [5]. The popped form of makhana seeds is where their commercial value lies. The starchy white puffs are promoted as a premium dry fruit product of makhana and are both very wholesome and delicious. Makhana seeds are widely used and have been found to have therapeutic effects used in Chinese and Ayurvedic remedies for the treatment of a number of illnesses, including renal disease, ongoing diarrhea, severe leucorrhea, and splenic hypofunction (Kumari *et al.*, 2019) [6]. Makhana seeds have a calorific value of 362 Kcal/100g in their raw state as opposed to 328 Kcal/100g in their popped state. However, because to the high ratio of leucine to isoleucine amino acids in its seeds, its biological value is modest (about 55). Good quality Makhana, also known as Rasgulla (or lava), makes up around 54% of pops following 35 and 11 percent of the medium-quality Murra and the low-grade, respectively called thurri (Kumari *et al.*, 2019) [6]. Trace metal analysis of whole and puffed starch gave values for Cu, Fe, Ca and Mg in both seed meal and whole starch of less than 1, 100, 1000 and 2000 ppm, respectively. Corresponding values for purified starch were 800, 80, 200 and 100 ppm, respectively (Jha *et al.*, 1991) [3]. Foxnut is used as an antioxidant, antiaging, antidiabetic and it has so many medicinal value (Tehseen *et al.*, 2020) [11].

2. Nutritional Aspects of Makhana

Makhana is an aquatic cash crop with high carbohydrate, protein, and low-fat content. Makhana contributes high market value, 1.72% consumption out of 3.46% production remain

it loose as wastage. The makhana production of about 80% is a market surplus (Khadatkar *et al.*, 2020) ^[4]. The raw makhana contains 76.9% carbohydrates, 12.8% moisture, 9.7% protein, 0.9% phosphorus, 0.5% minerals, 0.1% fat, 0.02% calcium and 0.0014% iron. In popped makhana 84.9% carbohydrate, 4% moisture, 9.5% protein, and 0.5% fat. Makhana had high medicinal value and it support the cotton industry highly. Makhana supported good treatment for respiratory, circulatory, digestive, and reproductive systems. Biochemical analysis of makhana seed had a high protein content of 15.6% and 1.36% fat, makhana plant composition is been illustrated in table 1. The calorie value of 100g of raw and puffed makhana gives 362kcal and 328kcal. Due to its high protein and fat content, the makhana is similar to almonds, walnut, cashew nut, and coconut. Makhana reported 16 types of amino acids in the kernel. The essential amino acid index (EAAI), chemical score (CS), and biological value (BV) of Makhana are similar to fish. Compared to eggs the higher content of arginine, alanine, and tyrosine in protein and amino acid composition (g/16 g N) in Makhana. Net protein utilization (NPU), true digestibility (TU), and apparent digestibility (CE) of makhana are given as 49.3, 89.3, and 69.1. These NPU, TU, and CE of makhana were lower than the soybean, egg, and cow milk (Khadatkar *et al.*, 2020) ^[4]. The makhana is rich in macro as well as micronutrients as well as a good source of minerals. Cu, Na, Ca, Fe, and Mg these trace metals have been reported by different researchers. The vegetative part of the makhana contains a good amount of N, P, and K. The high content of the P, Fe, and Zn is due to the muddy field condition. The makhana also contains a high amount of vitamins such as vitamin A and vitamin C ranging from 62.23 to 63.84 IU/g and 0.18% to 0.20% respectively (Khadatkar *et al.*, 2020) ^[4]. Due to high nutritional value and uniqueness of makhana importance and the market value of makhana been increasing day by day. Makhana seed also called as black diamond (Kumar *et al.*, 2016) ^[5]. The makhana has high content of carbohydrate of 78%, the carbohydrate is in the form of starchy dimension in makhana. The makhana has only 0.1% fat and contain high amount of minerals. Makhana has a calorie content of 362Kcal in 100g of makhana in popped makhana it gives only 328Kcal in 100g. Biological value of makhana is very low it contribute high leucine to isoleucine ratio in makhana seed (Kumari *et al.*, 2019) ^[6]. Fox nut has higher nutritional value compared to other dry fruits such as walnut, cashew nut and almond (Tehseen *et al.*, 2020) ^[11]. Despite having a lower percentage level (10–12%) than other cereals, Jha (1987) discovered that makhana protein was nutritionally superior to several plant- and animal-based diets. According to size makhana different composition of minerals inn makhana it's been illustrated in table 2. The raw and puffed edible makhana pieces were found to have essential amino acid indices (EAAI) of 93% and 89%, respectively. Compared to the numbers for rice (83%), wheat (65%), and Bengal, these are higher grain (81.55%), soya bean (85.6%), amaranth (57.5%), and breast milk Fish (89.5%), cow's milk (80.8%), mutton (87.24%), and fish (85.2%) (Jha *et al.*, 1991) ^[3]. The 77% starch content was separated into amylose and amylopectin by Nath and Chakraborty (1985b). The former made up 25%. They discovered that starch, amylose, and amylopectin had average unit chain lengths of 29, 22, and 380 glucose units, iodine-binding capacities of 5.36, 21.2, and 0.10, and blue colour 0.3 l, 1.28, and 0.05, respectively, are the values. The ability of

iodine to attach to This proportion contained 0.47% amylose, according to amylopectin. Trace Cu, Fe, Ca, and Mg values were obtained from the metal analysis of whole and puffed starch less than 1, 100, 1000, and 2000 parts per million (ppm) in seed meal and whole starch, respectively. For pure starch, corresponding values were 800, 80, 200, and Similarly, 100 ppm (Jha *et al.*, 1991) ^[3].

2.1 Foxnut as an antioxidant

Antioxidant activity of foxnut related with medical condition such as proteinuria inhibition or diabetic nephropathy is the most important activity of makhana. Foxnut (*Euryale ferox* Salisb) extracts exhibit increased rates of radical scavenging behaviour when tested with DPPH, TEAC, and CAT (Catalase) SOD (Superoxide Dismutase) activity, lowering power, and is a potent antioxidant because it prevents lipid peroxidation. As well increases cell viability and protects against H₂O₂ driven apoptosis and increases the performance of certain antioxidant enzymes. A significant source of natural antioxidants is foxnut. The potential to treat diabetes and hyperlipidemia and used as functional foods and dietary additives. They contain kaempferol, a flavonoid. Flavonoids are anti-inflammatory agents and a free radical's effect (Tehseen *et al.*, 2020) ^[11].

2.2 Foxnut as an antiaging

The most potent antioxidants that can eliminate free radical intermediates, stop chain reactions, and function as a fighting agent have been shown to be amino acids. The most important amino acids present in Foxnut are leucine, isoleucine, methionine, cysteine, arginine, and glutamine. The precursors to creatine are the amino acids arginine and methionine. are essential for having healthy skin, hair, and nails. acquired creatine, Methionine and arginine play a critical role in maintaining good skin. Additionally, creatine is crucial for the metabolism of cells in the body. Creatine provides energy to the cells, allowing for the creation of connective tissue, cells, and metabolism within the skin. Creating taurine from cysteine lowers the diabetes risk cellular influence (Tehseen *et al.*, 2020) ^[11].

2.3 Foxnut as an anti-diabetic

It is a serious medical illness brought on by a diverse collection of metabolic diseases characterised by impaired protein, starch, and fat metabolism as a result of a combination of inherited and environmental factors. It significantly affects patients' health, quality of life, and lifespan regarding the health care system's economies. It is a serious medical disease brought on by a diverse category of metabolic disorders brought on by faulty carbohydrate and fat metabolism and protein metabolism brought on by a combination of inherited and environmental factors. It significantly affects patients' health, quality of life, and lifespan regarding the health care system's economies. It is a serious medical disease brought on by a diverse group. Reactive oxygen species (ROS) are free radical-producing poisons like streptozotocin (STZ) or the pro-inflammatory conditions of an autoimmune infiltration [20]. Additionally, oxygen-free radicals are created in greater quantities in diabetes individuals and may be crucial in the majority of diabetic complications, such as diabetic nephropathy, neuropathy, and retinopathy (Tehseen *et al.*, 2020) ^[11].

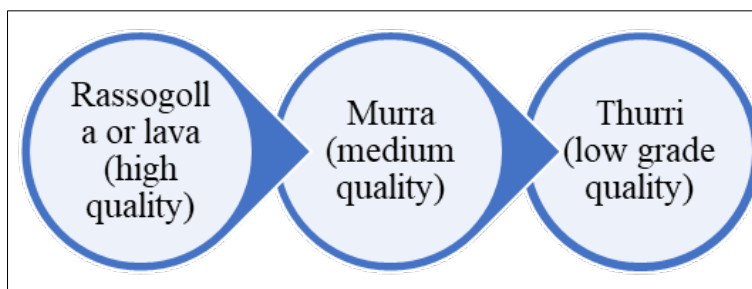


Fig 1: Types of makhana according to quality

Table 1: Chemical composition of plant parts

Constituents	Roots	Rhizome	Leaf infolded	Inflorescence bud	Petiole	Leaves
N%	0.712	0.612	0.618	0.181	0.160	0.196
K(mg/kg)	2120	2120	1760	1840	1920	1940
Na(mg/kg)	1120	1440	840	560	1240	1480
P(mg/kg)	1677	3195	43.96	5715	2321	2519
Zn(mg/kg)	56.1	39.6	46.2	52.8	42.9	46.2
Cu(mg/kg)	8.3	8.3	8.3	8.3	12.5	8.3
Mn(mg/kg)	100	13.10	87.5	62.5	87.5	118.8
Fe(mg/kg)	2236	2210	1736.5	1447.1	2394	1946.9

Source: Adopted from (Dutta *et al.*, 1986) ^[2]

Table 2: Chemical composition

Constituents	Fruit sheath	Small seed	Middle-sized seed	Superior seed	Prepared makhana	Husks
N%	0.165	1.46	1.56	1.51	1.13	-
K (mg/kg)	1180	160	160	240	160	760
Na (mg/kg)	1320	200	240	180	200	800
P (mg/kg)	5318	1863	2397	2715	2397	4038
Zn(mg/kg)	66	46.2	42.9	52.8	66	66
Cu(mg/kg)	16.7	8.3	8.3	8.3	8.3	8.3
Mn (mg/kg)	25	25	35	25	15	25.0
Fe(mg/kg)	1841.7	105.2	684	678.0	1105	118.4

Source: Adopted from (Dutta *et al.*, 1986) ^[2]

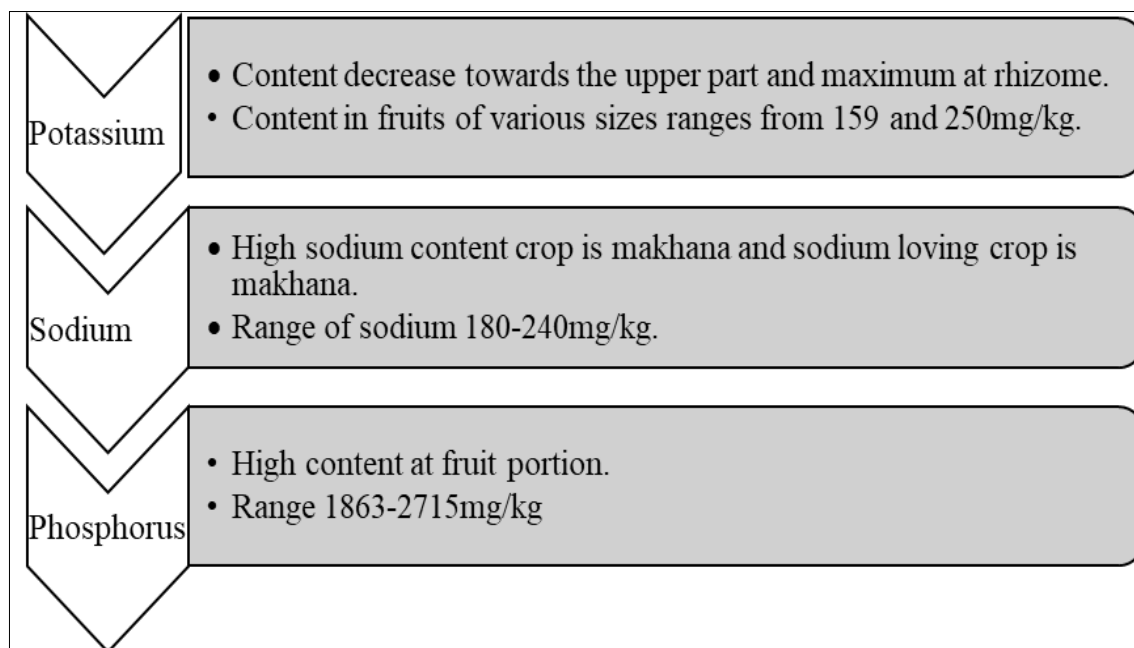


Fig 2: Different components in makhana and their role

Therapeutic Potential of Makhana

In India as well as in China Makhana had good medicinal importance. It is used for the treatment of various diseases like respiratory, circulatory, digestive, excretory, and

reproductive systems. Since Makhana is easily available it is a rich source of natural antioxidants. It can be used in the pharmaceutical and medical industries. It is also used for the treatment of diseases like spleen, polyuria, spermatorrhoea,

gonorrhoea, articular pains, micturition, seminal loss, kidney problems, chronic diarrhoea, leucorrhoea, and beri beri. In makhana presence of anti-aging amino acids in higher concentrations like glutamine, cystine methionine, and arginine (Khadatkar *et al.*, 2020) [4]. Components in the makhana seed with antioxidants activity and their synergistic antioxidant effects in makhana may be important reasons for the therapeutic effect of the makhana seeds to reduce proteinuria. Qualitative analysis for various secondary metabolites in makhana extract been illustrated in table 3. Makhana is considered a good source of natural antioxidants and hence, used for the prevention of diabetic nephropathy (Khadatkar *et al.*, 2020) [4]. The total antioxidant potential of the native and modified makhana flour samples was analyzed by evaluating their scavenging activity on DPPH radical (Biswas *et al.*, 2020) [1]. The ethanolic extract of the seed showed the presence of gallic acid, protocatechuic acid, gallic acid ethyl ester, 5,7-dihydroxychromone, daucosterol, 5,7-dihydroxy-6-40 -dimethoxyflavone, b-sitosterol, cyclo(Ile-ala), cyclo(pro-ser), cyto(leu-ala), 5, 7, 30, 40, 50 -pentahydroxy-flavone, 5,7,40 -trihydroxy-flavone, isolaticiresinol-9-O-b-D-glucopyranoside, a-tocopherol, b-tocopherol, and d-tocopherol. Makhana Seeds had a high impact on stomach ache, seminal loss (spermatorrhea), articular pain (rheumatism), spleen (bile disorder), reproduction (parturition), gonorrhoea, and diabetes (Dutta *et al.*, 1986) [2]. Medicinal properties been also reported for makhana seeds, and it is widely used in Ayurveda and Chinese preparations for the treatment of a variety of diseases, such as kidney failure, chronic diarrhoea, excessive leucorrhoea and hypofunction of the spleen (Kumari *et al.*, 2019) [6]. The traditional ayurvedic medicines in India holds medicinal benefits to diseases such as vata and pitta disorders (Kumari *et al.*, 2019) [6].

Table 3: Qualitative analysis for various secondary metabolites in makhana extract

S. No	Compound	Leaf extract	Seed extract
1.	Alkaloids	+	+
2.	Glycoside	-	+
3.	Phenols	+	+
4.	Tannins	+	+
5.	Saponins	-	+
6.	Flavonoids	+	+
7.	Steroids	+	+

Source: Adopted from Parray *et al.*, (2011)

Roasted fox nuts contain higher phytochemicals with increased antioxidant activity. In comparison with other nuts, the makhana had higher total phenolic content (ranging from 346.02 to 470.62 mg GAE/100 g) than macadamias (46 mg GAE/100 g), cashews (137 mg GAE/100 g), Brazil nuts (112 mg GAE/ 100 g) and almonds (239 mg GAE/100 g). But pistachios and walnut have opposite trends that are pistachios have (867 mg GAE/100 g) and walnuts (1625 mg GAE/100 g). Whereas, the flavonoid content of makhana (4.43 mg CE/g) was lower as compared to cashews (5.20 mg QE/g), almonds (4.58 mg QE/g), and pistachios (13.74 mg QE/g). TPC and TFC of makhana have been affected by roasting. Roasting ultimately increases antioxidant activity. TPC was 36% higher in roasted nuts (470.62 mg GAE/100 g) as compared to the control (346.02 mg GAE/100 g). A similar increase in TFC (7%) was also reported in roasted nuts as

compared to the control (4.15 mg CE/g). It exhibits a higher ability to scavenge DPPH free radicals (79.13%), as compared to roasted cashews (59.99%), pistachios (74.20%), and almonds (78.1%) when we compare roasted fox nuts with other nuts in terms of antioxidant activity. In conclusion, total phenols and flavonoids are variable among different nuts but roasted fox nuts exhibit higher antioxidant capacity than most of the widely consumed nuts (i.e., cashews, pistachios, and pistachios). Roasting affects both the nutritional and bioactive characteristics of foods (Liaquat *et al.*, 2022) [7].

Foxnut as traditional medicine

A crucial plant used in both Indian and Chinese medical medicines is foxnut. It is used to treat a variety of illnesses affecting the reproductive, excretory, digestive, and respiratory systems. In addition, it is utilised to treat spleen illnesses, articular aches, micturition, polyuria, spermatorrhea, and gonorrhoea persistent diarrhoea, severe leucorrhoea, and beriberi are all symptoms of the kidneys. A good immunostimulant that increased humoral immunity is foxnut. Suggests used by the mother who had the baby to boost immunity. This is a medicinal herb that's commonly utilize.

in traditional remedy in India and China 3000 years ago. Fox nut seeds are used

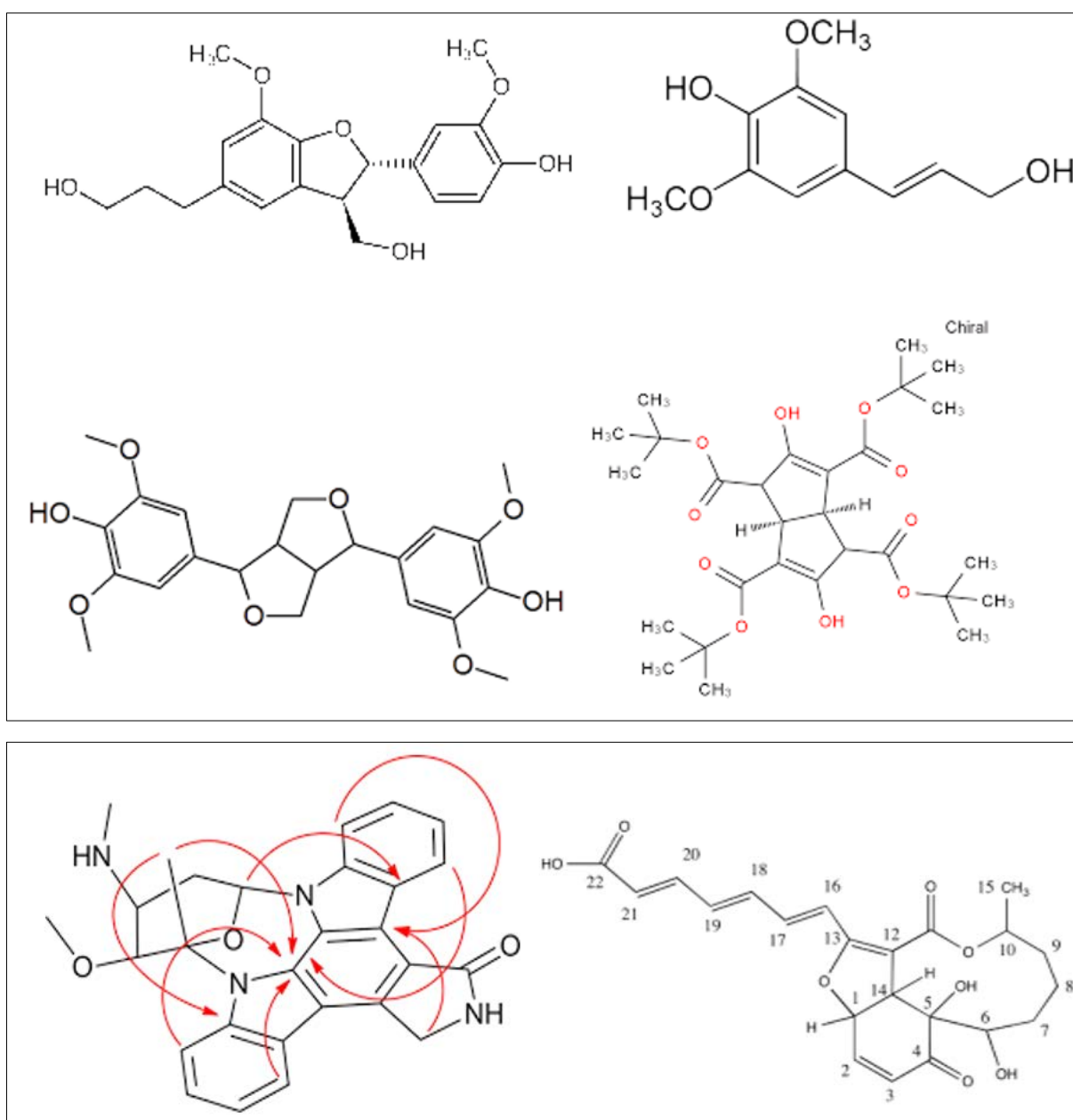
in ayurvedic preparations. This protects the coronary heart and is likewise useful for anaemia. Makhana is an crucial factor used to guard the spleen and kidneys. It includes low sodium and excessive potassium, which reduces blood stress and includes very low ranges of monosaturated fats that save you blood sugar from rising. In comparison, Blood Pressure and diabetes additionally have to regulate conditions such as neuralgia, incontinence and arthritis (Tahseen *et al.*, 2020). The presence of drummine, a sesquiterpene alkaloid, may explain why the leaves are useful against rheumatism. It was discovered that a leaf infusion was effective against challenging parturition. In China, it was discovered that leaf ash cooked with fermented rice (lautsao) could trigger labour. Flowers are believed to have the ability to suppress seminal gleet and are utilised as tonics. The seeds are utilised in the Unani system preventing dysmenorrhoea (Jha *et al.*, 1991) [3].

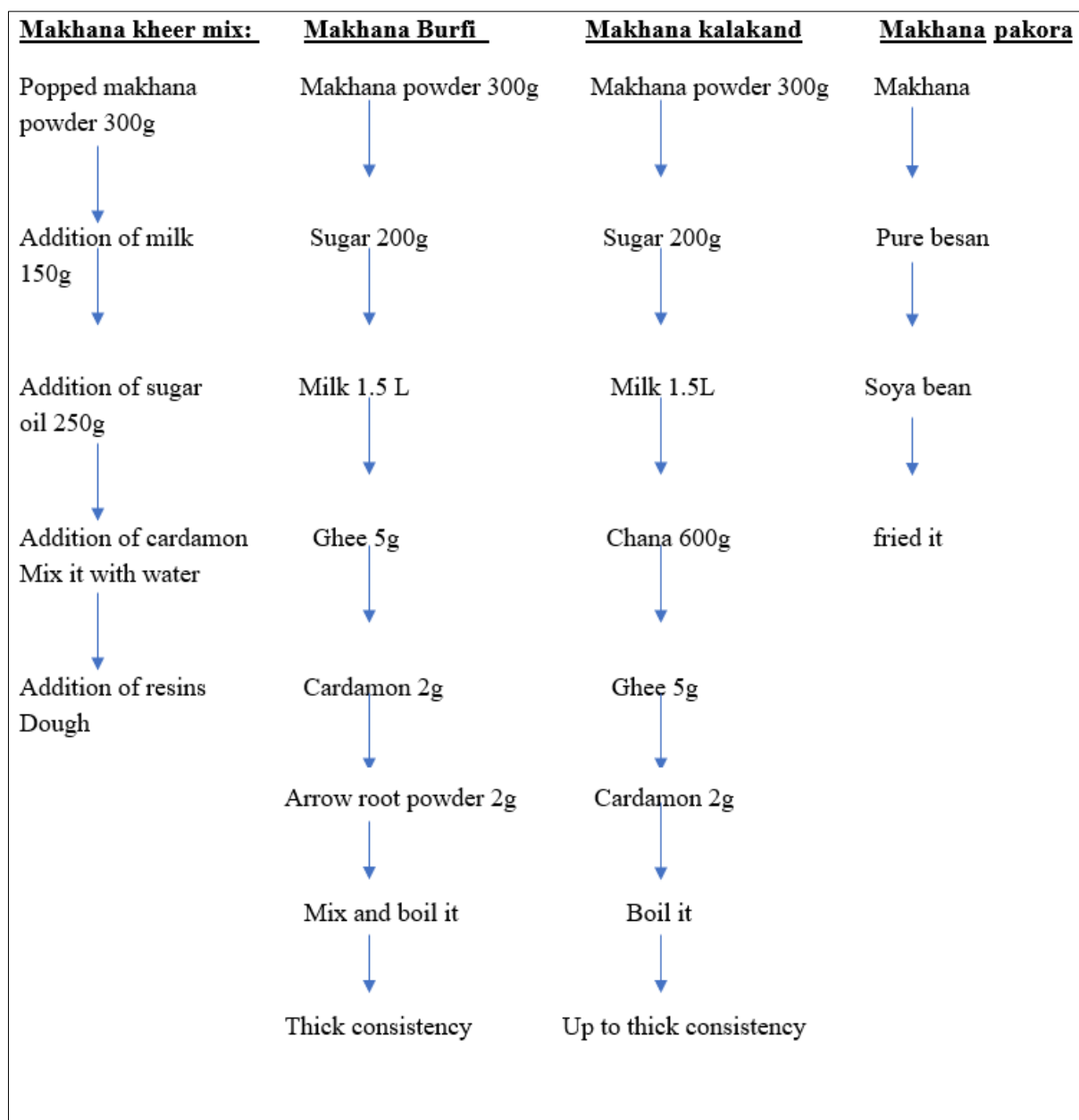
Since the makhana, a nutrient-rich product popped makhana and had several uses. Popped makhana is used for the preparation of several dishes and it is also used to mix with other vegetables to prepare dishes like dal makhana. Raw popped makhana can be eaten directly. And the roasted makhana can be served with tea or coffee, roasting can be done with salt and ghee or other oils. It's very difficult to handle popped makhana in raw form since it is very bulky. The development of processed products from makhana will certainly increase the value of makhana and its consumer demand in the market will increase. Compact packing of makhana will help handling easy and shelf life also increases. By adding some popular flavors like chili, onion, tomato, pudina, butter, etc. mix with makhana. Several companies prepare makhana snacks in the form of small attractive packs or containers. Different companies in India produce makhana with these specialties like Shakti Sudha Industries, Patna are also offering makhana atta (Makhana flour mixed with wheat flour), Makhana bhujia, Makhana flakes, cookies, etc in addition to roasted flavoured makhana pop. Research and preparation of value-added products of makhana done by

ICAR RCER Research Centre for Makhana, Darbhanga. Technology has been developed for the preparation of Makhana Kheer Mix and Makhana powder. Some work on the preparation of different dishes like Makhana Burfi, Makhana Kalakand, Makhana curry, Makhana chapatti, etc. has also been done (Pratap, 2021) [8]. The provided seeds had been made into a stuffing meal. Many products designed for consumption contain carefully handled and finely grated foxnut. It frequently appears in the instruction of many different recipes. Consisting entirely of milk, including pudding and kheer. fried and roasted Foxnuts that have been seasoned with oil and spices are very popular snacks. The seeds are consumed as a snack after being fried in addition to inside the knowledge of curries and vegetable meals. The *Euryale ferox* Salisb. product is consumed raw in salad and chutney forms. Foxnut powder is structured into gluten-free loose biscuits for humans with a gluten allergy and for those who are fasting (Tehseen *et al.*, 2020) [11].

Compounds Responsible for Antioxidant Property

Identification of 3 new sesquiolignans called euryalins A-C (1-3) and 16 known compounds, of which were isolated for the first time from this plant, in addition to 5,7, -trihydroxyflavanone. The antioxidant potential of partial isolates was evaluated using DPPH radical scavenger assay and mesangial cell assay. Compounds 2, rel-(2R,3β)-7-O-methylcedrusin, -syringylglycerol-8-O- -(sinapyl alcohol) ether (5) and (b)-cystaresinol (7) were found. be the most active in the DPPH test, while compounds 2, 7, (1R,2R,5R,6S)-2-(3, -dimethoxyphenyl)-6-(3, -dihydroxyphenyl)- 3,7- dioxabicyclo [3.3.0] octane and buddlenol E can significantly inhibit high glucose-stimulated reactive oxygen species production in mesangial cells. The results suggested that *E. feroxi* seeds can be considered as an excellent source of natural antioxidants and useful in the prevention of diabetic nephropathy (Song *et al.*, 2011) [10].





Source: Adopted from (Tehseen *et al.*, 2020) ^[11]

Future Aspects

In a world that is looking for vegan, plant-based, gluten-free, non-GMO nutrition, makhana has a promising future. You have a winner when you combine the seeds' high nutritional value—100g has hardly any fat and around 9.7g of protein, 14.5g of fiber, and trace levels of calcium, iron, magnesium, and potassium. Moreover, the snack, flavorless on its own, lends itself to seasoning. Already, vacuumed-packed makhana packets in flavors such as sour cream and onions, peppery tomato, tikka masala, Piri-Piri, and even chocolate, are available in supermarkets.

Current Status of Makhana

Makhana has a high nutritional content and several health advantages, thus demand has been steadily rising recently. The modern makhana in India is devoured all across the nation. nonetheless, commercial Makhana production is only permitted in a few parts of West Bengal, Assam, Manipur, and North Bihar, and through a network, reaches all of the country's largest cities including producers, processors, local

vendors, and other dealers. commissions, remote wholesalers, wholesalers, both customers, and retailers. Farmers in production areas are estimated to receive About 55% of the final retail price in the local market. However, when it comes to makhana, its share declines rapidly. Due to the high price of pops, they are sold in distant markets receive. Retail margins are his second most important Components in final price accounting for about 19% Of the retail price of Puff Macana. For exports, the export potential is Not used yet. Currently, India exports only 1-2 of her. Percentage of total production. almost 100 tons of Pop Makhana are exported to other countries (Singh *et al.*, 2020) ^[9].

Conclusion

This article is discussed about the importance of makhana. Some crops in this vast cosmos have been overlooked due to agronomic, cultural, genetic, financial, and societal factors. More than 7,000 people, according to ethnobotanical surveys Only a few plant species are grown or harvested from the forest. On a broad scale, 150 crops are sold worldwide. This

review emphasises a plant species that will require greater consideration in the near future because it significantly contribute to the enhancement of human health overall. Due to a shortage, the usage of this nourishing superfood is restricted of information and study. Policymakers have not given foxnut enough attention since it cannot compete with important commodity crops that command high economic interest.

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