



Foxnut (*Euryale ferox* Salisb.): A Health Promising Fruit

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Abstract

Foxnut (*Euryale ferox* Salisb.) commonly known as makhana is a flowering plant with gigantic and floating leaves. Foxnut is a highly-valued aquatic crop due to its high amount of carbohydrate, protein, ash, crude fiber, minerals and phytochemical content. Foxnut plant species can take part remarkably towards the betterment of human health, fight against hunger and providing traditional medicinal effects. Owing to their powerful medicinal properties, foxnut pops are used against many human disorders that affect the respiratory, circulatory, gastrointestinal, excretory and reproductive system. It is used as an important source of natural antioxidants with antidiabetic and antihyperlipidemic potential and used as food additives. The amino acids arginine and methionine are the creatine precursors that are necessary for beautiful skin nails and hairs. Creatine obtained from arginine and methionine plays a crucial part for healthy skin. It is used as a functional food for the treatment of diabetes and the alleviation of its complications. *Euryale ferox* Salisb seed reduces hyperglycemia that could be triggered by the release of insulin from the remnant. It contains low sodium and high potassium, which reduces blood pressure and contains very low levels of monosaturated fat that prevent blood sugar from rising. It has all the nutritional and potential health benefits necessary to be regarded as a super food.

Keywords: Foxnut; Antioxidant; Phytochemical; Therapeutic Effect; Anti-diabetic

Abbreviations

ICAR-RCER: Indian Council of Agricultural Research-Research Complex for Eastern Region; DPPH: 2,2-Diphenyl-1-Pichrylhydrazyl; TEAC: Trolox-Equivalent Antioxidant Capacity; CAT: Catalase; SOD: Superoxide Dismutase; ROS: Reactive Oxygen Species; STZ: Streptozotocin; HBAC: 2β-Hydroxybetulinic Acid 3β-Caprylate

Introduction

Foxnut (*Euryale ferox* Salisb.) is an aquatic nut crop commonly known as Makhana in Hindi and Punjabi, gorgon nut or prickly water lily, which comes under water lily family, *Nymphaeaceae* although it is occasionally considered as *Euryalaceae* [1]. It is grown in saline perennial bodies of water such as land depressions, oxbow lakes, swamps and ditches [2]. A single foxnut plant produces

about 100 seeds and in one ha of pond area there are 10,000 plants. The yield of raw Makhana seed is around 1.8 - 2.0 t/ha of pond area [3]. The plant produces white starchy seeds that are edible. Raw or fried foxnut contains significant amounts of essential amino acids and contains no cholesterol. Various studies concluded the physical and hygroscopic properties of foxnut that make it ideal for use in formulating food for infants [1].

Foxnut distribution is highly restricted to tropical and subtropical regions of South-East and East Asia [4]. The main distribution of *Euryale* was found in Pakistan during the taxonomic field survey (2005 - 2009) of Marala Headwork's Wetlands, North West side of Punjab, a species of genus *Euryale* as *E. ferox* Salisb., found along the left bank of River Chanab, facing Village Gondal, District Gujrat [5]. In India North Bihar are the principle areas of its cultivation [6].



Figure 1: Foxnut (*Euryale ferox Salisb.*).

Foxnut (*Euryale ferox Salisb*) is stem less, prickly, thin and dense rootstock aquatic plant. The leaves are submerged, oblong, orbicular with a width of around 6 - 100 cm; reddish green above, purple below and densely spiny. The flowers are solitary, submerged, and epigenous with four permanent, thorny sepals placed on the torus above the level of the ovary, together with many seriate petals. The lower, multicarpellary ovary grows into a spongy berry like densely prickly fruit, the size of an orange, and producing 30 - 40 pea size seeds with stiff black seed coat and a mucilaginous aril. The pulpy aril keeps the seeds floating for a couple of days dehiscing, before them finally settling down to the bottom of the water [7]. The optimal temperature range for its proper growth and development is 20 - 35°C, relative humidity 50 - 90% and annual rainfall 100 cm - 250 cm [8]. Traditionally foxnut is cultivated as a sole crop and water sources are utilized for just seven months from February to August for growing foxnut [9]. The transplanting may be achieved from the first week of February to the second week of April depending upon the accessibility of field and nursery. The system reduces the duration of foxnut crop up to four months [10,11].

Foxnut seeds germinate when they are inside the water [12]. At variegated stages of seed germination, various biochemical adjustments were elucidated. The protein content has been reported to increasing with age. Gamma irradiation can develop new varieties of this crop with better commercial characteristics. Some studies were also conducted in ICAR-RCER, Patna on genetic variation in selected 24 pure lines of foxnut for morphological and yield contributing traits. The study revealed that five lines of the 24 pure lines Sel-5, Sel-6, Sel-13, Sel-14 and Sel-24 differed substantially from others in some specific characteristics. It was observed that the Sel-6 genotype have the maximum yield potential (983.8 g/

plant). Sel-6 was the first ever Foxnut variety named as "Swarna Vaidehi" (*E. ferox*) with a production potential of 3.0 t/ha compared with 1.4 - 1.6 t/ha in conventional cultivars. This variety sowed seed yields 60 per cent higher than local yields. It also found the nutritional profile rich in micronutrients and essential amino acids [13].



Figure 2: a: Leaves (upper surface), b: Leaf (Lower Surface) c: Flower, d: Fruit, e: Seeds, f: Popped Foxnut.

Nutritional value of foxnut

Foxnut (*Euryale ferox Salisb.*) has low fat content, high carbohydrates contents, protein and minerals. The calorific value of raw seeds and puffed seeds is 328 kcal/100g and 362 kcal/100g respectively. Nutritional studies indicates that edible portion of the seed contains 12.8% moisture, 9.7% protein, 0.1% fat, 76.9% carbohydrate, 0.5% mineral contents and 1.45% iron in addition to a good fraction of sugar, phenol and ascorbic acid. Amino acid index is higher than that of staple foods, which indicates its unique food quality [14]. Foxnut possess a superior nutritional profile relative to other dry fruits such as walnut, almond, cashew nut or coconut in contents of sugar, proteins, phenol and ascorbic acid [15].

Foxnut as an antioxidant

Foxnut has paramount antioxidant activity related with medical condition such as proteinuria inhibition or diabetic nephropathy [1]. An equity among free radicals and antioxidants is desired for proper functioning of the body [16]. Foxnut (*Euryale ferox Salisb*) extracts demonstrate elevated rates of radical scavenging behavior with DPPH, Trolox-equivalent antioxidant (TEAC), CAT (Catalase) activity, reducing power, SOD (Superoxide dismutase) activity, and inhibits lipid peroxidation, hence a powerful antioxidant. It also facilitates cell viability, defends against apoptosis induced by H₂O₂ and enhances the activity of various antioxidant enzymes [17]. Foxnut is utilized as a substantial source of natural antioxidants with antidiabetic and antihyperlipidemic potential and used as

food additives as well as a functional food [18]. They carry a flavonoid called kaempferol. Flavonoids are antioxidants and reverse the impact of free radicals [7].

Foxnut as anti-aging

Amino acids have been constituted as the most effective antioxidants, which can eradicate the free radical intermediates, end chain reactions and act as a fighting agent. The amino acids named as Leucine, isoleucine, methionine, cysteine, arginine and glutamine are the most essential amino acids found in Foxnut. The amino acids arginine and methionine are the creatine precursors that are necessary for beautiful skin nails and hairs. Creatine obtained from arginine and methionine plays a crucial part for healthy skin. Creatine also plays as a momentous part in cell metabolism in the body. Creatine accommodates the cells with energy and thus enables the production of the connective tissue, cells and metabolism of the skin. Taurine produced from cysteine decreases the diabetic influence in cells. Arginine, which generates nitric oxide inside the tissue, recovers the elasticity of the arteries and veins, thus enhancing the flow of blood. Some other amino acids, such as isoleucine and proline, help the body in growth and development [19].

Foxnut as an anti-diabetic

It is a severe medical condition arising from a heterogeneous group of metabolic diseases caused by compromised starch, fat and protein metabolism resulting from the involvement of a number of hereditary and environmental influences. It has a huge effect on the health, standard of living and lifespan of patients and on the economies of the health care system [21].

Diabetes is a metabolic disease characterized by high blood glucose levels. It is the cause of inadequate pancreatic function and secretes the insulin hormone. Foxnut is a sweet and sour dry fruit, as it includes starch and protein that is effective for diabetic patients and acts as an antidiabetic agent [21].

Reactive oxygen species (ROS) produced either by pro-inflammatory environments of an autoimmune infiltrate or by free radical generating toxins such as streptozotocin (STZ) [20]. Moreover, in diabetic patients, oxygen-free radicals are produced in larger amounts and may play an essential role in most diabetic complications including diabetic nephropathy, neuropathy and retinopathy.

Essential compounds have been extracted from *Euryale ferox Salisb* seeds which have been found as antioxidant in nature and are associated with their therapeutic applications as an inhibitor

of proteinuria or diabetic nephropathy. HBAC (2 β -hydroxybetulinic acid 3 β -caprylate) is an efficient antidiabetic agent with numerous restorative effects arbitrated by avoiding the degradation of β cells, preserving the histological composition of the pancreas and liver, and preserving the endogenous antioxidant enzymes in the liver. It is also used as a functional food with HBAC (2 β -hydroxybetulinic acid 3 β -caprylate) as a component in the treatment of diabetes and the alleviation of its complications [21].

Euryale ferox Salisb seed extract protects β -cells from ROS-mediated degradation by improvising ratios of antioxidant enzymes and reducing hyperglycemia that could be triggered by the release of insulin from the remnant [21]. Dietary taurine has a blood cholesterol-lowering effect in young overweight adults and it is essential for cardiovascular function, and controls body weight and helps in function of the central nervous system and diabetes [19].

Foxnut as traditional medicine

Foxnut is a medicinally decisive plant reported in both Indian and Chinese medicinal products. It is used for treatment of various diseases like respiratory, circulatory, digestive, excretory and reproductive systems. It is also used to treat diseases of spleen, polyuria, spermatorrhoea, gonorrhoea, articular pains, micturition, kidney problems, chronic diarrhea, excessive leucorrhoea and beriberi. Foxnut is a good immunostimulant which stimulated humoral immunity and also recommends using by conceived mothers [13].

This is a medicinal herb which is generally used in traditional medicine in India and China 3000 years ago. Fox nut seeds are used in ayurvedic preparations. This protects the heart and is also beneficial for anemia. Makhana is an essential component used to protect the spleen and kidneys. It contains low sodium and high potassium, which reduces blood pressure and contains very low levels of monosaturated fat that prevent blood sugar from rising. In comparison, Blood Pressure and diabetes also tend to regulate conditions such as neuralgia, incontinence and arthritis [22].

It can be used in the medical and pharmaceutical industries, as it is an easily accessible source of natural antioxidants [23]. Miscellaneous seed components with antioxidant activity and their synergistic antioxidant effects may be important reasons for the proteinuria reduction therapeutic effects of seeds. It could therefore be considered a good source of natural antioxidants, and thus used to prevent diabetic nephropathy [24]. An effective constituent of "Su-Shin" traditional Chinese medicine that is tonic to boost growth in young children [15]. The fibers in the Foxnut seeds help the body

evict waste and block toxin accumulation. This helps maintain blood pressure and relieves numbness. Some of Foxnut's curing properties include inhibiting insomnia, palpitation and irritability, strengthening the heart and treating anemia. It has been found that *Euryale ferox Salisb.* is effective in treating pyodermas, hernia and leucorrhea [17].

Foxnut as super food

The seeds were sold and used as a stuffy dish. Many items that are ready to eat are made with sorted and grated foxnut as an ingredient. It is often used in the preparation of different dishes based on milk, including kheer and pudding. Roasted and fried Foxnut sprinkled with oil and spices are consumed as popular snacks. After frying the seeds are used as snack as well as in the preparation of vegetable dishes and curries [17]. The fruits of *Euryale ferox Salisb.* are taken raw in a salad and chutney forms [15]. Gluten free biscuits are prepared from foxnut powder for people with gluten allergy and for fasting people [25].

Preparation of pua by adding foxnut powder to overcome protein and minerals deficiencies [26]. Development of nutritious and stable infant food formulation for improvement of cognitive and behavioral in children [1]. The application of popped foxnut inside the bakery product has been detected and used. The popped and puffed foxnut can be used to strengthen the gluten-free bun or bread's texture and consistency [27]. Different sweet like makhana kalakand and makhana barfi are prepared from makhana flour. Makhana chapatti and makhana cabbage is also prepared by formulating makhana flour with other edible flour. The products based on makhana are low in sugar content and gives good expansion, color which attract the health conscious people [22].

Conclusion

In this large universe, there are some crops which have been ignored for agronomic, cultural, genetic, monetary and social reasons. According to ethno-botanical surveys, more than 7,000 plant species are cultivated or collected from the forest, but only 150 crops are sold on a large global scale. This review highlights a plant species which needs more attention to near future as it can contribute appreciably towards the improvement in human health overall. The use of this nutritious super food is limited due to lack of knowledge and research. Foxnut has not attracted sufficient attention from policy-makers as it cannot compete with major commodity crops, commanding large economic interests. This fruit

is the blessing which remained unexplored and use only for local consumption. Timely research and investment can save food for the next generations arriving on an already ailing earth.

Conflict of Interest

There is no conflict of interest.

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