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BR Jana
ICAR-RCER, Research Centre for Makhana, Basudeopur, Darbhanga, Bihar, India

Anuradha Srivastava
ICAR-RCER, Research Centre Ranchi, Namkum, Ranchi, Jharkhand, India

Md. Idris
ICAR-RCER, Research Centre for Makhana, Basudeopur, Darbhanga, Bihar, India

Correspondence
BR Jana
ICAR-RCER, Research Centre for Makhana, Basudeopur, Darbhanga, Bihar, India

New makhana (*Euryale ferox* Salisb.) processed products for health benefit

BR Jana, Anuradha Srivastava and Md. Idris

Abstract
Makhana or gorgon nut is an important non cereal food from aquatic resources. People now a day's prefer to protein rich food in their eating habit for sound health as compared to carbohydrate rich products. For our present study conducted at Research Centre on Makhana, Darbhanga, India during 2015-2016, we prepared Makhana barfi and kalakand as sweets and makhana chapatti and makhana pokora as evening snack food from makhana flour and mixed flour. Makhana flour was prepared from drying of seed at 30-35 ^{0}C for 42 hours followed by crashing and sieving. The water and oil absorption capacity of makhana flour were 6.39 g gel/g and 2.09 g gel/g, respectively whereas moisture content and bulk density of the flour were 9.15 % and 696.74 kg /cm^3, respectively. As the sugar content of the products were very less and having medium to high calorific value, it might be fitted for normal as well as diabetic and B.P. patient. Makhana-wheat chapatti (1:1) was very excellent product, which had calorific value of 317.24 cal/100 g product and might improve overall status of health of aged people. Makhana kalakand was low free sugar (16.66%) and high protein (11.53%) sweets as compared to makhana barfi (19.33% sugar & protein 5.40%). From this study we concluded that kalakand as sweets and makhana chapatti (1:1) as evening snack food were the best for health conscious people in terms of their calorie intake. Resultant products from makhana flour had very good expansion, appearance, colour and taste and may be exploited as evening snack food potentially.

Keywords: Makhana flour, chapatti, sweets, calorie and protein and fat

Introduction
Makhana (*Euryale ferox* Salisb.) is one of the most important aquatic nut crops produced in India. It is known for its higher protein and carbohydrates content. It generally produces edible nut and it is superb medicinal plant used in ancient medicine in India and China 3000 years ago. The seeds of fox nut are used in ayurvedic preparations (Jha *et al*., 1991) [9]. It contains 11.16 % protein and 75.04 % carbohydrates. It strengthens the heart and is very useful in anemia (Das *et al*., 2006) [6]. Makhana is an important ingredient which is used to strengthen spleen and kidneys. It contains low sodium and high potassium which reduces Blood Pressure and since it contains very low amount of mono saturated fat, which prevent to increase blood sugar level. Besides, B.P and diabetes it also helps to control diseases like neuralgia, incontinence, chronic diarrhea and arthritis (Jha *et al*., 1991) [9]. *Euryale ferox* seeds are rich source of macronutrient like Ca and Mg and also many micro-nutrients (Shankar, 2016) [19]. It is nutritious and easily digested (Singh and Arora, 1978) [21]. Antioxidant activity of raw seed was maximum than that of popped, which was due to the outcome of processing at high temperature (Haleema *et al*., 2016) [7]. Popped makhana is well known product in Mithilanchal of Bihar (Mandal, 2010) [12]. Since ancient times, the people of the Mithila region using makhana for various domestic consumable products like popped, halwa and kheer. In Kashmir fruits are edible. The seeds are consumed in raw or roasted forms as well as flour of dried seeds was used as nutritious bread (CSIR, 1952) [4]. Makhana contains unique glycosides combinations which are helpful for element of cardiovascular diseases. (Das *et al*., 2006) [6]. Different kinds of sweets were prepared from different fruits and nuts (Bandopadhyaya *et al*., 2006) [3]. Among them Cashewnaut barfi was most famous as reported by Rao (1993) [18], Parmar (2012) [14] and Parmar and Sharma (2016) [14]. Also reported about production of fig burfi and halwa in Maharastra, India. But no scientific information and document is available for product like makhana or gorgon nut burfi. To make it scientific representation and use of different kinds of sweet like makhana, barfi and kalakand, the new edibles like chapatti and pokora have been showed in the present study. The aim of the research paper is to provide scientific way of making makhana products for further up gradation of knowledge and protocols development for preparing different kinds of makhana based products in our day to day life. Sweets like, makhana barfi, kalakand and makhana chapatti (1:1) contain high calories and low sugar which are not only nutritious but also healthy food for health conscious

people.

Materials and Methods

A. Prepapration of makhna flour

Fresh makhana seeds were cleaned in fresh water and air dried at shade. Hot blower was used for drying the seed. After drying, seeds were crushed to remove seed coats and separated the kernels. The murky smell of makhana seed coats and other inert materials associated with it were easily removed by this process. Seeds were distempered, generally, by exposing these at 30-35 ^{0}C for 42 hours. Low temperature and long duration drying was very effective for not only removing seed coat with drying but also kernels which ware minimally processed. Then kernels were easily separated from husk like other nuts i.e. almond and walnut. Generally, kernel weight: husk weight was 60:40. After separation from husk, kernels were smashed thoroughly after that sieving was done to get seed coat free from fine white flour. As the drying and threshing of seed was done under shade and at very low temperature, flour had full of antioxidant property which was very beneficial for human health. The water absorption capacity and oil absorption capacity of different flours were measured according to Sosulski *et al*. (1976) [22]. In 10 ml distilled water 1 gm of flour was taken mixed and kept in ambient temperature (32.0 ^{0}C) for ½ hr and centrifuged 30 min at 3000 rpm. In case of measurement of oil absorption capacity, soybean oil is used (Specific Gravity 0.9092). The rest procedure was same as that of earlier. The volume of 100 g of the flour with air space was measured in a measuring cylinder (250 mL). After tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, the apparent (bulk) density was calculated (Jones *et al*., 2000) [10] based on the weight and volume. Bulk density is the dry weight of the flour (g) divided by volume of natural flour (cm^3) and finally expressed as Kg/cm^3.

B. Biochemical composition. For determining mineral content, seed kernel (whole) were washed initially by tap water followed by dilute hydrochloric acid (0.05N) 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 a 80-mesh sieve (180 µm). Protein was measured by Lowry method and carbohydrates was determined by the Anthrone method (Ranganna, 1997) [17]. Dried samples (1g) were digested with diacid mixture (HNO3:HClO4:9:4). After digestion and extraction of samples, total P was determined with the vanodo-molybdophosphoric acid yellow-colour method total K and Na were determined with the flame photometric method. Water-soluble Ca and Mg were determined by the Versanate method. Water-soluble Fe and S were measured with an atomic absorption spectrophotometer (Analyst 100, Perkin Elmer, and Norwalk, CT, USA). Total dietary fiber was measured by Prosky method and calculated from 'residue weight–weight of (protein+ash)' and expressed by per cent (Prosky, 1990) [16] and fats were determined by Modified butyrometric method Ali and Khan (1988) [1].

C. Preparation of different products: Makhana flour, arrowroot flour wheat flour, besan raw and chopped cabbage were used to prepare different products like makhana barfi, makhna kalakand and makhana pokara. Different procedures are given below:

Makhna Barfi was prepared from raw makhana powder (300g), sugar (200g) milk (1.5 liters) pure ghee (5g), elachi powder (2g), arrowroot powder (2g) and then mixed them properly for ready to boil. The boiling temperature was 130-140 ^{0}C for 30 minutes to thick consistency then cut into small pieces after cooling.

Makhana Kalakand was prepared from raw makhana powder (300g), sugar (100g), channa (600 g), milk (I.0 lit), pure ghee (5g) and elachi powder (2 gm). The boiling temperature was 130-140 ^{0}C for 30 minutes to thick consistency and then cut into small pieces after cooling of the resultant mass.

Makhna Chapatti: The recipe of the makhana chapatti was raw makhana powder (250g) bread wheat (Atta: 250g) and pure ghee or oil (10 ml). The dough was made with the help of water. Chapatti was then fried in a non stick pan at about 150 ^{0}C (for roasting).

Makhna Pokora was made from makhana raw powder (250 g), pure besan (150g) and soybean oil (250 g). Pokora was fried and scan on spoon at about 150 ^{0}C.

D. Determination of qualities of the prepared products

After preparation of different products, protein content was determined by Lowry method (Gopalan *et al*., 2004) [6] and carbohydrates was determined by Anthrone method Ranganna (1996) [17]. Fats and free sugars were calculated from raw materials used in preparation of sweets, chapatti and pokara. Overall calorie was determined by raw material used and from their composition. TSS of the products was determined by the hand held refractro-meter. Consistency or solidity was determined by the penitro-meter readings.

Results and Discussion

Functional properties of the different flours

At first we studied the functional properties of different flours viz; makhana, wheat, besan and arrowroot, which were used in different products directly. A close perusal of the Tabe-1 revealed that makhana flour had the lowest moisture (9.15%) followed by besan flour (9.6%). However, wheat and arrowroot powder showed the higher moisture % in the flours viz (13.04%) and (12.15%), respectively. The higher water absorption capacity was observed in makhana (6.39 g gel/ g dry sample) followed by arrowroot (6.01 g gel/ g dry sample). The results were in corroborated with the findings of Aprianita (2014) [2]. The makhana flour had the highest oil absorption capacity (2.09 g gel/ g dry sample). The lowest oil absorption capacity was found in arrowroot (0.93 g gel/ g dry sample) similar results were obtained by Mohammad *et al*. (2014) [13]. Among the four flours used in making different product, the makhana flour had the highest bulk density (696.74 kg /cm^3). This might be due to compact kernel and fine texture of particle than other flours. This is mainly because of less granulation/ aggregation. As aggregation and finer particle content decrease, bulk density increases. Since the bulk density is related to the combined volume of solids and pore spaces, hence the flour with lower pore space will have higher bulk densities, Hence, makhana powder have very high bulk density as compared to other flour. Moreover, due high gluten content in finer particles that form small clumps and together it had higher volume after moisture/water soaking. Regarding biochemical composition. makhana kernel powder had moisture, carbohydrates, protein, fat and fiber content of 10.5, 74.9, 11.2,0.5 and 0.5% respectively [Fig-1 (a).]. The similar results were also obtained by Shankar *et al* (2010) [19], and Jana and Idris (2018) [8]. The makhana kernel was rich source of K (260 mg/100g), S (70 mg/100g), Mg (60 mg/100g), and Ca (50 mg/100g) but Sodium (Na=15mg/100g) [Fig -1 (b)]. The results were in accordance with the findings of Shankar *et al* (2010) [19], and Jana and Idris (2018) [8].

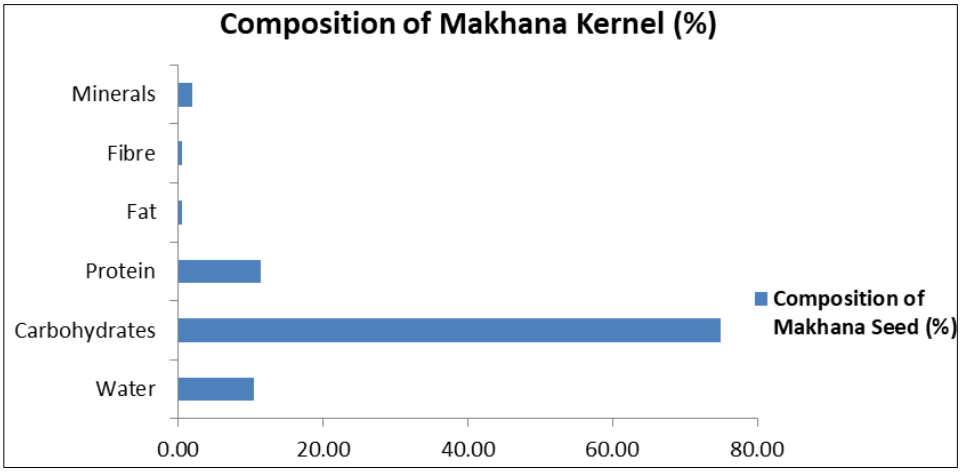

Fig 1(a): Compositions of makhana kernel (Bio-molecules)

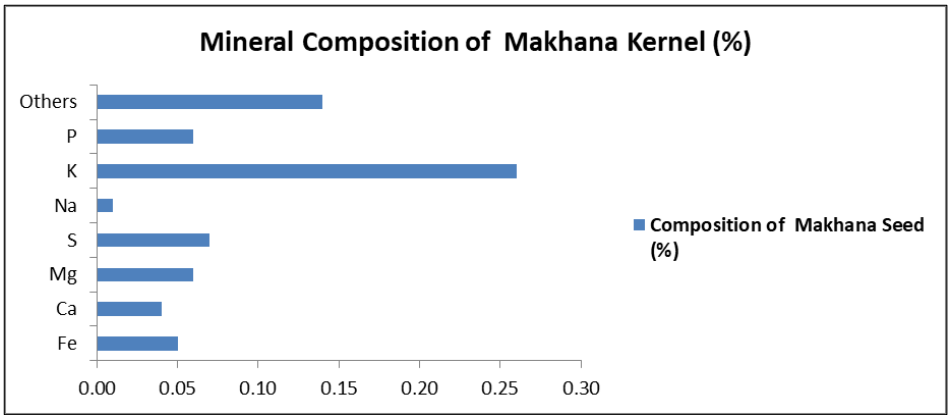

Fig 1(b): Compositions of makhana kernel (Minerals and vitamins)

Proximate composition of different makhana based products

As we used makhana raw powder and boiled the product at 140-150 ^{0}C for 30 minutes, all the nutrient elements were well preserved in these products. The glutamic acid content of the foods were very high about 17 mg/100g powder which gave the voluminous resultant product for makhana barfi and kalakand. We obtained 1.5 kg of cooled product from 2.0 kg raw materials, which accounted for 30 pieces of each products. Makhana chapatti was excellent product when it was mixed with wheat flour at a ratio of 1:1. In case of chapatti, from 500 g mixed flour we got 680 gm products. Both the flours were mixed with sufficient water to make dough for making chapatti by frying with little amount of oil and ghee. Data pertaining to Table-2, showed that the makhana chapatti was calorie rich products. 100 g chapatti provided 317.24 calorie energy followed by makhana kalakand which had 232.83 cal energy from same product. However, in respect of protein content of the product, makhana kalakand was the best (11.53 %) followed by makhana chapatti which exhibited the protein content of 10.57 %. Among the sweets makhana kalakand showed the minimum sugar percent (16.66%). But in case of evening snack food makhana chapatti recorded the minimum sugar content of 0.24 %. With regard to carbohydrates makhana chapatti had highest value (64.04%) but fat content was found to be highest in makhana pokora (12.71 %).

Sensatory analysis of makhana products

The organoleptic evaluation was performed based on Hedonic (10 points) scale. It has been found that according to colour and texture the makhana chapatti had the maximum (<9.0) value followed by Makhana kalakand (Table-3). The taste and appearance score of makhana kalakand was the best 8.4 and 8.1 respectably. The results were corroborated with the findings of Parmar (2012) [14] and Parmar and Sharma (2014) [14]. When we calculated total points regarding the best product, the makhana kalakand scored the highest number (8.32). The term texture is related to the feeling of food within the mouth and as such it includes a wide range of attributes that can be measured with instrumental methods or with sensory tests. Texture properties arise from structural elements and the way they respond to forces or deformations (in the mouth), eventually resulting in breakdown of the structure and the flow of the material. The texture of the product makhana barfi was excellent as compared to other products. Shete *et al*. (2011) [20] also reported that cashewnut barfi or kajukatli had very fine texture and mouth feel.

Quality and shelf life of the products

After making the product, we placed in safe place for overnight to cool down and product can get a thick consistency. Post prepared qualities regarding moisture (%) and firmness (kg/cm^2) were recorded in the next days and shelf life was studied at an ambient room temperature for week long. Table-4 showed that the maximum moisture content was found in makhana pokora (12.78%) followed by makhana kalakand (11.23%) and lowest moisture (9.15 %) was found in makhana barfi. Similar results were also obtained in respect of kajukatli by Parmar and Sharma (2014) [14] where moisture content of the product was 8.4 %. As long as makhana chapatti was hot firmness was low but during storage firmness increases. After 24 hours the firmness of makhana chapatti was the highest (1.65 kg/cm^2). Parmar and

Sharma (2016) [14] also prepared kajukatli from cashew nut and also obtained similar results in respect of firmness of the product. With regard to shelf life of the product, makhana barfi had the maximum shelf life of 8.5 days followed by makhana kalakand (5.5 days) after that these products showed pale in appearance as compared to fresh. The minimum shelf life was found in makhana pokara (1.2 day).

Table 1: Functional properties of different flours used in makhana products.

Flours	Moisture (%)	Water Absorption Capacity (g gel/g dry sample)	Oil Absorption Capacity (g gel/g dry sample)	Bulk Density (kg/cm3)
Makhana	9.15[b]	6.39[a]	2.09[a]	696.74[a]
Wheat	13.04[a]	1.39[c]	1.45[b]	477.25[c]
Besan	9.6[b]	1.34[c]	1.22[b]	480.63[c]
Arrowroot	12.15[a]	6.01[b]	0.93[c]	612.78[b]
(CRD)CD at 5%	1.46	0.33	0.28	43.92

Table 2: Different components of makhana products.

Products	Calorie/100g Product	Protein (%)	Carbohydrate (%)	*Fat (%)	*Free Sugars (%)
Makhna Barfi	160.33[d]	5.40[d]	25.47[c]	04.37[c]	19.33[a]
Makhana KalaKand	232.83[b]	11.53[a]	21.53[d]	08.73[b]	16.66[b]
Makhana Chappatti (1:1)	317.24[a]	10.57[b]	64.04[a]	02.49[d]	0.24[d]
Makhana Pokara	211.46[c]	8.85[c]	30.19[b]	12.71[a]	2.82[c]
CD at 5%	19.74	1.01	3.28	1.42	0.22

*Fats and Free sugars were calculated from raw material used.

Table 3: Organoleptic taste scores for different makhana products

Name of the products	Colour (10 points)	Texture (10 points)	Taste (10 points)	Appearance (10 points)	Total Score Average (10 points)
Makhana Burfi	7.2[c]	8.0[b]	7.7[c]	7.0[c]	7.47[c]
Makhana Kalakand	8.6[b]	8.2[b]	8.4[a]	8.1[a]	8.32[a]
Makhana Chapatti (1:1)	9.0[a]	9.3[a]	8.0[b]	7.8b	8.22b
Makhana Pokara	7.0[c]	7.5[c]	7.2[d]	7.3[c]	7.32[d]
Significance ($p < 0.05$)	*0.35	*0.42	*0.28	*0.45	*0.12

*Mean ± standard deviation of ten panelists. Means in the same column with different letters are significantly different ($p < 0.05$)

Table 4: Characteristics and shelf life of different makhana products.

Products	Moisture (%) After 01 day	Consistency or firmness (Kg/cm^2)	Shelf Life (days)
Makhana Burfi	9.72[c]	0.95	8.5[a]
Makhana Kalakand	11.23[b]	0.72	5.5[b]
Makhana Chapatti (1:1)	6.92[d]	1.65	1.5[c]
Makhana Pokara	12.78[a]	1.13	1.2[c]
(CRD) CD at 5%	1.29	NS	1.7

Plate 1: Makhana Barfi

Plate 3: Makhana pokora

Plate 2: Makhana kalakand

Plate 4: Makhana-Wheat chapati (1:1)

Plates 1-4: Different products from makhana (Euryale ferox Salisb.) flour.

Conclusion

From the present study, we concluded that after preparation of makhana flour, different sweets viz; makhana barfi and makhana kalakand and snacks viz; makhana wheat chapatti (1:1) and makhana cabbage pokora can be prepared by the mixing makhna flour to other edible flours in different proportion successfully. Makhana based products are low in sugar content but had moderate calorific value moreover resultant products had very good expansion, color which may attract heath conscious people appreciably.

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