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E Jyothi
M.Sc. Student, Department of Life Sciences and Nutrition, Capital Degree and PG College, Shapur Nagar, Hyderabad, Telangana, India

Anil B
Head and Professor, Department of Life Sciences and Nutrition, Capital Degree and PG College, Shapur Nagar, Hyderabad, Telangana, India

Corresponding Author:
Anil B
Head and Professor, Department of Life Sciences and Nutrition, Capital Degree and PG College, Shapur Nagar, Hyderabad, Telangana, India

Preparation and quality characterization of Makhana Sesame Laddu

E Jyothi and Anil B

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Abstract
Makhana, also known as fox nuts or lotus seeds, is a popular ingredient in Indian cuisine. It is mostly developed in the state of Bihar, India and East Asia. The scientific name of makhana is *Euryale ferox*. The study was framed to standardised makhana laddu and to know quality parameters. The nutritional analysis of the selected sample A Makhana laddu had a energy 394.78 K. Cal, protein of 1.5 g/100 gm, carbohydrates of 82.57 g/100 gm, moisture of 8.23 g/100 gm, ash content of 1.2 g/100 gm, total fat of 6.5 g/100 gm, fiber of 1.5 g/100 gm, calcium of 60 mg/100 gm, and iron of 1.4 mg/100 gm. The antioxidant potential of Makhana Laddu after 30 days of storage. The results showed significant antioxidant activity, with a DPPH radical scavenging activity of [1278 ppm], FRAPS value of [9.797µmol], and ABTS radical scavenging activity of [76.07GAE/g], making it a promising food product with potential health benefits. Also, the microbial analysis showed the results such as for aerobic plate count below <10 CFU/g, yeast & molds as <10 CFU/g and Enterobacteriaceae showed results as absent in the sample. Makhana is rich in antioxidants, fiber and protein, it is gluten free and low in calories making the diet to support heart health, digestive health, bone health and help to manage blood sugar levels.

Keywords: Makhana, cuisine, nutritional parameters, sensory evaluation, antioxidant activity

Introduction
Makhana, otherwise called fox nuts or lotus seeds, is a customary Indian tribute got from the seeds of the *Euryale ferox* plant. This oceanic plant is tracked down principally in the stale waters of India and portions of East Asia. Makhana has been essential for Indian food and Ayurvedic medication for quite a long time because of its nourishing and restorative properties (Garg *et al*., 2016) [15]. Makhana is plentiful in protein, fiber, and fundamental minerals like magnesium, potassium, and phosphorus. It is low in fat and calories, going with it a known decision for wellbeing cognizant customers (Singh *et al*., 2017) [18].
Research features a few medical advantages related with makhana utilization. It has cell reinforcement properties that can help in diminishing irritation and oxidative pressure. Furthermore, makhana is known for its enemy of diabetic, hostile to corpulence, and cardioprotective impacts (Rajan and Pandey, 2018) [16]. Its low glycemic record makes it reasonable for diabetics, while its low-fat substance assists in dealing with weighting actually.
The wholesome profile of Makhana incorporates roughly 347 kcal of energy, 9.7 grams of protein, and a negligible fat substance of 0.1 grams. It is wealthy in carbs, with around 76 grams, and gives a lot of fiber, about 14 grams. The mineral substance highlights around 60 mg of calcium, 2.6 mg of iron, 118 mg of magnesium, 207 mg of phosphorus, and 350 mg of potassium, alongside around 1.6 mg of zinc. USDA National Nutrient Database for Standard Reference. Therefore, study chosen to formulate makhana laddu and to highlight the cultural significance and traditional importance of makhana of makhana laddu in Indian festivals and celebrations.

Materials and Methods
Material Procurement: Makhana, sesame seeds, Almonds, raisins, Jaggery and Ghee as required were collected from super market in Hyderabad, India. The present study was performed in Capital Degree and PG College, Hyderabad-500055, Telangana.

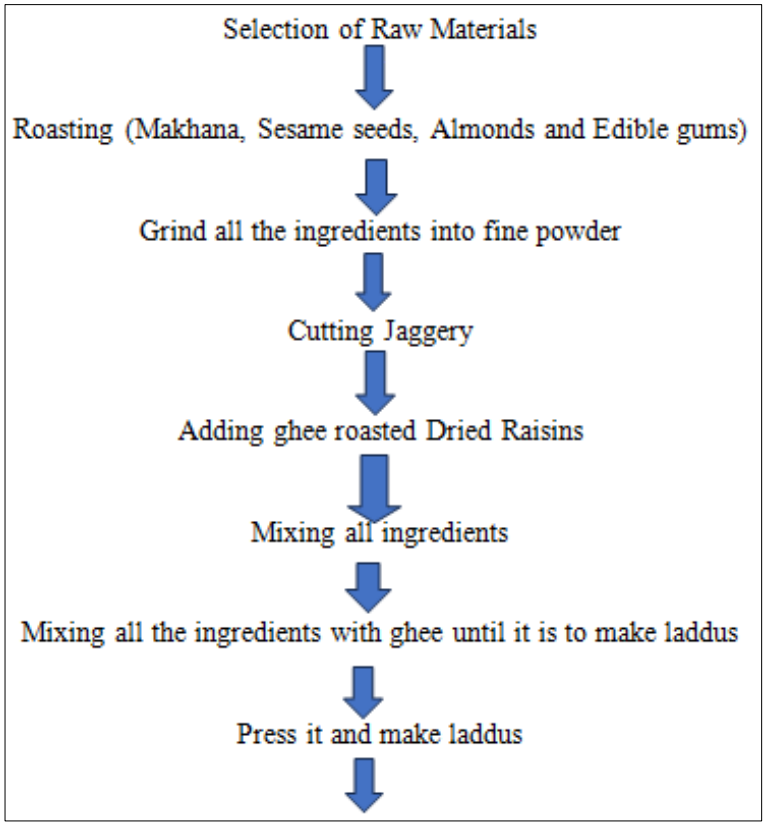
Preparation of Makhana laddu

Take the Makhana, Sesame Seeds and Almonds. Roast them and make fine powder and keep aside. Take a pan heat ghee and roast dry raisins in ghee, and also edible gums and make them into fine powder and keep aside. Now take all the flours Makhana flour, sesame seeds flour, Almonds flour, jaggery, edible gums flour, and raisins into a bowl and mix all of them with ghee until it is ready to make laddus. Then make the laddus and garnish it with almonds (Table 1).

Table 1: Formulation of Makhana Laddu

Sample Name	Makhana Flour (g)	Sesame seeds Flour (g)	Almonds (g)	Edible Gums (g)	Jaggery (g)	Dried Raisins (g)
Sample A	30 g	20 g	15 g	5 g	20 g	10 g
Sample B	25g	25g	15g	5g	20 g	10 g
Sample C	20 g	30 g	15g	5g	20 g	10 g

Fig 1: Makhana Laddu



Flow chart-1: Preparation of Makhana Laddu

Organoleptic Evaluation of Makhana Laddu

The sensory evaluation was carried out three samples of Makhana Laddu prepared Sample A, B and C by using a 7-point hedonic scale with panel of 20 judges considering 6 parameters such as colour, texture, aroma, taste, appearance, overall acceptability and identified best scores sample, the best score identified sample carried out for further analysis.

Nutritional Evaluation of Makhana Laddu: Proximate analysis is a set of methods used to determine the nutritional

composition of a food sample. It involves the measurement such as moisture, protein, fat, carbohydrates, fiber and ash.

Table 2: The nutritional evaluation of Makhana Laddu (Sample A)

Test parameter	Units of measurement	Methods
Energy	K. Cal	FAO
Protein	g/100 gm	AOAC 2001
Carbohydrate	g/100 gm	AOAC:985.29
Moisture	g/100 gm	AOAC:925.10
Ash	g/100 gm	AOAC:942.05
Total fat	g/100 gm	AOAC:920.39
Fiber	g/100 gm	AOAC:991.43

Energy determination
The energy present in the selected sample was calculated and presented in the table. Energy content of the food product was determined using the FAO method. (Food and Agriculture Organization of the United Nations, 2003).

Protein Determination
The AOAC 2001 by using Kjeldahl method, which is used for the determination of protein in the selected food sample. (AOAC International, 2001).

Protein (%) = (N x 6.25) / Sample weight (g).

Carbohydrates Determination
The AOAC 985.29 by using high-performance liquid chromatography (HPLC) method, which is used for the determination of carbohydrates in the selected food sample. (AOAC International, 2022).

Moisture Determination
The AOAC 925.10 21st Edition is a method for determining the moisture content in the selected food sample by air oven dry method. (AOAC International, 2022).

Moisture content (%) = (Weight of ash / Weight of the sample) x 100.

Ash Determination
The AOAC 942.05 is a method for determination of ash content in the selected food sample by gravimetric method. (AOAC International, 2022).

Ash content (%) = (Weight of ash/ Weight of the sample) x 100.

Fat Determination
The AOAC (Association of Official Agricultural Chemists) 20th Edition 2016 method (920.39) by Gravimetric determination, which is used for the determination of fat in selected food sample.

Fat (%) = (Weight of extracted fat / Weight of the sample) x 100.

Fiber Content
The AOAC 991.43 is a method for the determination of total fiber content in the selected food sample by enzymatic-gravimetric method. (AOAC International, 2022).

Total Dietary Fiber % (TDF) = [Initial weight of the sample (W1) – Weight of the protein residue (W2) – Weight of the ash residue (W3) +Weight of the filtered fiber residue (W4)] / Initial weight of the sample (W1) x 100.

Mineral Analysis of Makhana Laddu
The assessment of calcium and iron concentrations in the samples was conducted (Table 3). Calcium levels were quantified using the AOAC method 984.27, Similarly, iron content was analyzed employing AOAC method 985.35.

Calcium (Ca): The AOAC 948.27 is a method for the determination of calcium content in the selected food sample by Atomic Absorption Spectroscopy (AAS). (AOAC International, 2022).

Calcium content (%) = [Absorbance of sample solution (A) x Volume of the sample solution (V) x Dilution factor (DF) x 40.08)] / Weight of the sample (W) x 100.

Iron (Fe): The AOAC 985.35 is a method for the determination of iron content in the selected food sample by Atomic Absorption Spectroscopy (AAS). (AOAC International, 2022).

Iron content (%) = [Absorbance of sample solution (A) x Volume of the sample solution (V) x Dilution factor (DF) x 55.85)] / Weight of the sample (W) x 100.

Table 3: Mineral analysis of Makhana Laddu (Sample A)

Test Parameter	Units of Measurement	Methods
Calcium	mg/100 gm	AOAC 984.27
Iron	mg/100 gm	AOAC 985.35

Antioxidant Analysis of Makhana Laddu
The antioxidant activity of food samples was evaluated using assays: DPPH (2,2-diphenyl-1-picrylhydrazyl), FRAP (Ferric Reducing Antioxidant Power), and ABTS (2,2'-azinobis(3-ethylbenzothiazoline-6-sulfonic acid)) assays. Each assay was conducted following standardized procedures.

Table 4: Antioxidant activity of Makhana Laddu

Antioxidant activity	Units	Method
DPPH	ppm	Brand-Williams *et al*., 1995 [11]
FRAP	µmol Fe +2 /g	Benzie & Strain (1996) [10]
ABTS	GAE/g	Re *et al*., 1999 [17]

DPPH- (2, 2-Diphenyl-1-picryhydrazyl) is a method for determination of antioxidant activity in the selected food sample. (Brand-Williams *et al*., 1995) [11].

Antioxidant activity (%) = [(Absorbance of the DPPH solution without sample – Absorbance of the DPPH solution with sample) / Absorbance of the DPPH solution without sample control] x 100

FRAP – (Ferric Reducing Antioxidant Power) is a method for determination of antioxidant activity in the selected food sample. (Benzie and Strain, 1996) [11].

FRAP value (µmol TE/g) = (Absorbance of the sample-Absorbance of the blank) / (Absorbance of the Trolox standard – Absorbance of the blank) x Concentration of Trolox standard (µmol/ml) x Dilution factor

ABTS: (2,2'-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)) is a method for determination of antioxidant activity in the selected food sample. (Re *et al*., 1999) [17].

ABTS value (µmol TE/g) = (Absorbance of the sample-Absorbance of the blank) / (Absorbance of the Trolox standard – Absorbance of the blank) x Concentration of Trolox standard (µmol/ml) x Dilution factor

Microbial analysis

Microbial analysis such as aerobic plate count, yeast & molds and Enterobacteriaceae was carried out after 30 days of study by procedure followed by Indian standard method. (FSSAI Manual, 2nd Edn. 2022).

Statistical analysis

Data obtained from sensory analysis is subjected to mean and standard deviation and it was statistically calculated by ANOVA using a significance of P value 0.05.

Results and Discussion

Sensory Evaluation

In terms of Colour, sample A has a mean value of 6.85 with a standard deviation of 0.38 while sample B has a mean value of 6.80 with a standard deviation of 0.42 and sample C has a mean value of 6.55 with a standard deviation of 0.73 (Table 5). Regarding Texture, sample A has a mean value of 6.85 with a standard deviation of 0.38; while sample B has a mean value of 6.70 with a standard deviation of 0.55 and sample C has a mean value of 6.35 with a standard deviation of 0.83.For Aroma, sample A has a mean value of 6.85 with a standard deviation of 0.38, while sample B has a mean value of 6.75 with a standard deviation of 0.51 and sample C has a mean value of 6.40 with a standard deviation of 0.82.In terms of Taste, sample A has a mean value of 6.90 with a standard deviation of 0.32, while sample B has a mean value of 6.80 with a standard deviation of 0.42 and sample C has a mean value of 6.55 with a standard deviation of 0.73.For Appearance, sample A has a mean value of 6.80 with a standard deviation of 0.42, while sample B has a mean value of 6.65 with a standard deviation of 0.58 and sample C has a mean value of 6.30 with a standard deviation of 0.86.For Overall Acceptability, sample A has a mean value of 6.85 with a standard deviation of 0.38, while sample B has a mean value of 6.75 with a standard deviation of 0.51 and sample C has a mean value of 6.40 with a standard deviation of 0.83.These measurements provide an assessment of the sensory attributes for the three samples A, B, and C. Sample A generally tends to have higher mean values across all attributes, indicating a potentially better sensory experience compared to samples B and C.

Table 5: Sensory evaluation of Makhana Laddu

Sample	Colour	Texture	Aroma	Taste	Appearance	Overall acceptability
Sample- A	6.85 ±0.38	6.85±0.38	6.90±0.32	6.85±0.38	6.80±0.42	6.85±0.38
Sample- B	6.80±0.42	6.70±0.55	6.80±0.42	6.75±0.51	6.65 ±0.58	6.75±0.51
Sample- C	6.55±0.73	6.35±0.83	6.55±0.73	6.40±0.82	6.30±0.86	6.40±0.83

Table 6: ANOVA test for sensory evaluation of Different samples of Makhana Laddu

Source of variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Statistic	P – value	F crit
Between groups	0.585	2	0.292	57.88	0.675	2.765
Within groups	0.075	15	0.005			
Total	0.661	17				

Nutritional value of Makhana Laddu (Sample A)

The nutritional analysis of selected sample A Makhana laddu had a energy 394.78 K. Cal, protein of 1.5 g/100 gm, carbohydrates of 82.57 g/100 gm, moisture of 8.23 g/100 gm, ash content of 1.2 g/100 gm, total fat of 6.5 g/100 gm, fiber of 1.5 g/100 gm, calcium of 60 mg/100 gm, and iron of 1.4 mg/100 gm.

Table 7: Nutritive Value of Makhana Laddu (Sample A)

Test parameter	Results	Units
Energy	394.78	K. Cal
Protein	1.5	g/100 g
Carbohydrate	82.57	g/100 g
Moisture	8.23	g/100 g
Ash content	1.2	g/100 g
Total fat	6.5	g/100 g
Fiber	1.5	g/100 g

A study conducted by Ekal, V. (2024), the nutritional analysis results for wheat makhana laddu (30:70) showed moisture content as 12.2gm which shows high in this when compared to makhana sesame laddu, ash 2.4gm, which is high when compared to makhana sesame laddu, energy 10 kcals, which have very low kcal as compared to makhana sesame laddu, carbohydrate 78.9gm shows low when compared to makhana sesame laddu, protein 2.54gm,the protein levels are high when compared to makhana sesame laddu, crude fat 12.98gm.

Mineral Analysis of Makhana Laddu (sample B)

The mineral content of the selected sample B as, calcium 60 mg/100 gm and iron 1.4 mg/100 gm (Table 8).

Table 8: Mineral content of Makhana laddu

Test Parameter	Results	Units
Calcium	60	mg/100 gm
Iron	1.4	mg/100 gm

Antioxidant parameters of makhana laddu

The results showed significant antioxidant activity, with a DPPH radical scavenging activity of [1278 ppm], FRAP value of [9.797µmol], and ABTS radical scavenging activity of [76.05 GAE/g] (Table 9). These findings suggest that Makhana Laddu retains its antioxidant properties even after 30 days, making it a promising food product with potential health benefits.

Table 9: Antioxidant parameters of makhana laddu

Test parameter	Units	Results
DPPH	ppm	1278
FRAP	µmol	9.798
ABTS	GAE/g	76.05

Microbiological Parameters of Makhana Laddu after 30 days Storage

The microbial analysis of the sample B after 30 days of storage as follows (Table 10), the aerobic plate count was below 10 CFU/g, yeast and mold count was below 10 CFU/g and Enterobacteriaceae was absent in the sample. (FSSAI Manual, 2nd Edn. 2022).

Table 10: Microbiological Parameter of Makhana Laddu

Test Parameter	Units	Results
Aerobic plate count	CFU/g	<10
Yeast & molds	CFU/g	<10
Enterobacteriaceae	CFU/g	Absent

A study conducted by Ekal, V. (2024) [12], shows the results as follows, the total yeast and mold count was not detected in the sample about 30 days of storage whereas makhana sesame laddu detected the yeast and mold as below 10 CFU/g.

Conclusion

This study successfully created Makhana Laddu with improved nutritional benefits and longer shelf life by combining Makhana flour with Sesame flour in various ratios. Among the three samples tested organoleptically, the sample A i.e 60:40 (Makhana: Sesame) ratio was determined to be the most preferred. The nutritious blend, showcasing superior antioxidant and microbial properties. This blend demonstrated an impressive 30-day shelf life with minimal microbial activity, indicating its potential as a viable commercial food product. The results of this study emphasize the potential of Makhana-Sesame blends in developing nutritious and long-lasting food items, offering a valuable contribution to both the food industry and consumers.

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