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Formulation and Evaluation of Khakhra Incorporated with Makhana (*Eyurale ferox*)

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Abstract

Euryale ferox (also known as foxnut), belongs to the family Nymphaeaceae. It is grown in India, China, Japan, and Korea. It is a highly nutritious food, abundant in nutritional, medicinal value, and bioactive compounds such as carbohydrates, protein, and fiber. The product was formulated by trial-and-error method by evaluating using 9 - point hedonic scale. Based on the results, it could be concluded that Treatment 2 Khakhra is best accepted. which represents the obtained value is greater than the other sample given for sensory evaluation. Makhana contains high-quality easily digestible 11.16 % protein. Makhana, contains the least fat and is good from a health point of view the aim of this study was to investigate the benefits of combining makhana with khakhra, a popular Indian snack. The study found that incorporating makhana into khakhra resulted in a product that offered a protein packed snack product. Moreover, the addition of makhana enhanced the nutritional value of the khakhra by providing a reliable source of protein, dietary fiber, and antioxidants. These components contribute to improved satiety, digestive health, and overall well-being. The objective is to assess the physical and mechanical properties, evaluate the microbial and antioxidant activity of the product and to determine the shelf life and cost of the product. The results revealed that the inclusion of makhana powder improved the nutritive value of the khakhra. The antioxidant activity was evaluated using the DPPH, results significantly increased the antioxidant activity of the formulated product. In conclusion, the study demonstrated that incorporating makhana into khakhra not only enhances the taste and texture but also increases the nutritional benefits.

***Key words*:** Antioxidant, Foxnut, Health food, Medicinal value, Incorporated, Nymphaeaceae

Makhana grown mostly in eastern India, (*Euryale ferox* Salisb.) is a significant aquatic cash crop. When scientifically grown in the field, especially in an area with enough water available during the growing season, makhana productivity and production can be significantly increased, and in addition to better makhana farming [1]. Because of their many applications including processed seeds used as fast food because of their high nutritional value, industrial, and medicinal makhana seeds are highly well-liked throughout the nation.11.6% of the high-quality, easily digested protein in makhana is present. Makhana is the lowest in fat content and is considered healthy. Makhana is a major source of high-quality carbs, containing around 75.04%. Makhana decreases blood cholesterol levels and is not a particularly reliable source of dietary fiber. Additionally, it is a high source of aspartic acid, arginine, leucine, valine, and glutamic acid, which are among the necessary amino acids. In addition, it is regarded as having nutritional benefits [2]. Popular in Northwestern India, khakhra is a typical ready-to-eat snack or breakfast dish. Gujarat is a state where this product enjoys great popularity. Because it requires no additional processing at the point of consumption, requires little packaging, and has a long shelf life, it is a popular snack when traveling. A wholesome snack for an Indian diet. Makhana is a notable source of high-quality carbohydrates, comprising approximately 75.04% of its nutritional content. This makes it an excellent energy source. Additionally, makhana has been found to have properties that help in reducing blood cholesterol levels, contributing to cardiovascular health. However, it is important to note that while makhana offers numerous health benefits, it is not a particularly reliable source of dietary fiber.

An extremely light-weight, nutrient-dense, crispy, and crunchy snack. favored by kids and teens alike. available in an extensive variety of tastes. Makhana is an extremely lightweight, nutrient-dense, crispy, and crunchy snack. Favored by kids and teens alike, it is available in an extensive variety of flavors, making it a popular and versatile choice for a healthy snack. It is typically consumed with tea, coffee, pickles, butter, ghee, chutney, and vegetables with cheese or yoghurt on top. These are convenient to transport, and the majority of Gujaratis pack them for on-the-go snacks. Phytochemicals found in makhana have been investigated for advantages to bone health. These substances may promote the growth of new bone, prevent the resorption of existing bone, and boost overall bone health [3]. Euryale ferox seed is consumed medicinally or for food in

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China. The study on Makhana revealed it to contain significant antioxidant activity, which may be associated with its medical applications as a proteinuria inhibitor of diabetic nephropathy [4]. Iron, omega-3 fatty acids, dietary fiber, proteins, other vital minerals, and phytochemicals are all abundant in makhana [5].

MATERIALS AND METHODS

Material requirement selection of raw material: A raw material for preparation of khakhra was whole wheat flour, besan flour, edible oil, salt, red chili powders, turmeric were purchased from the local market of the Tamil Nadu, Chennai. Makhana were purchased from organic store, Chennai.

Processing equipment: Sieve, electronic weighing balance, stainless-steel pots, grinder (mixer).

A. *Preparation of makhana flour*

Purchasing of makhana was done followed by cleaning and removing any impurities. Dried and grinded the makhana into a fine powder using a grinder or a food processor, followed by sieving the ground makhana powder to remove any large particles or uneven texture.

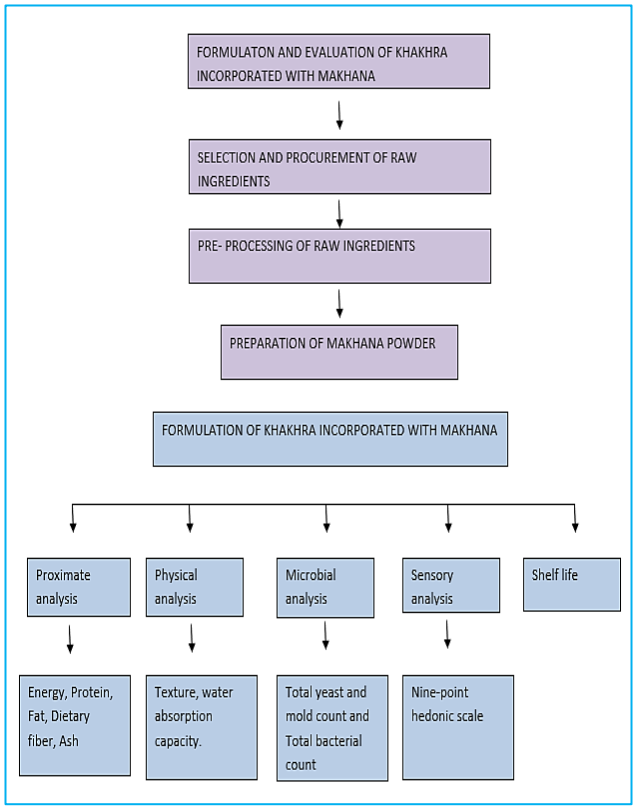

Fig 1 Flow chart for the development and preparation of Makhana powder incorporated in khakhra

Packaging material

Plastic packaging prevents air from entering by creating a sealed barrier around the khakhra. The packaging material is specifically designed to be airtight, which means it doesn't allow air to pass through. This helps in preserving the freshness of the khakhra by preventing oxygen from reaching it. Oxygen can cause the food to spoil or become stale, so the airtight packaging helps to keep the khakhra crispy. The intent of this packing is usually to remove oxygen from the container to extend the shelf life of foods and, with flexible package forms, to reduce the volume of the contents and package. Packaging material was used to increase the shelf life of khakhra.

Experimental procedure

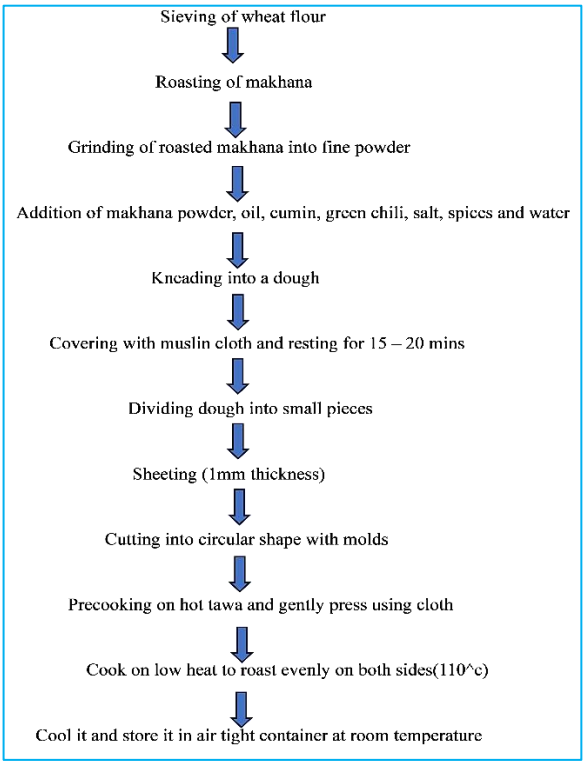

Fig 2 Flow chart for the development and preparation Makhana khakhra

Variation table

In addition to the basics, three distinct variants were performed. The variations are achieved by incorporating varied proportions of Makhana Powder into the khakhra.

Table 1 Variation table of Formulation and evaluation of khakhra incorporated with makhana powder

Treatment	Whole wheat flour (g)	Makhana powder (g)	Besan flour (g)	Oil (g)
Control	100	0	10	5
T_1	80	20	10	5
T_2	70	30	10	5
T_3	60	40	10	5

Chemical analysis

Determination of moisture, protein, fat, fiber, ash, by AOAC [6], AACC [7] method and the carbohydrates are estimated.

RESULTS AND DISCUSSION

According to a study, attempts were undertaken to create khakhra, a nutrient- dense health food, as a functional and nutritious product. Product that has been prepared for evaluation of the prepared khakhra's sensory acceptability and nutritional qualities. To estimate the shelf life, the prepared product was further assessed for microbiological characteristics and storage. The following is a discussion of the collected results.

Sensory analysis of value added khakhra

Sensory analysis of value added khakhra of sample, Control, T_1, T_2, T_3 was conducted based on color, flavor, texture, taste, and overall acceptability with the help of sensory evaluation on 9-point hedonic scale and the results are depicted in (Table 2).

Table 2 Sensory analysis of value added khakhra

	Appearnace	Colour	Taste	Texture	Flavour	Overall acceptability
Control	7.6 ± 1.54	7.7 ± 1.66	7.2 ± 0.95	7.4 ± 1.05	7.5 ± 1.91	7.6 ± 1.20
T_1	6.7 ± 1.52	7.5 ± 1.80	6.9 ± 1.95	7.65 ± 1.57	6.9 ± 1.38	7.45 ± 1.46
T_2	8.75 ± 0.93	8.6 ± 0.72	8.7 ± 0.62	8.8 ± 0.64	8 ± 0.60	8.8 ± 0.60
T_3	6.5 ± 1.05	7.1 ± 1.25	6.9 ± 1.49	7 ± 1.07	6.5 ± 0.46	6.5 ± 1.20

Value represents mean ± standard deviation

Organoleptic characteristics are the most important properties of khakhra for its consumer acceptability. The data pertaining to organoleptic evaluation showed that appearance, color, taste, texture, flavor, and overall acceptability score varies significantly with respect to khakhra each other [8-9]. The highest score was achieved by S2 (i.e. 8.8).

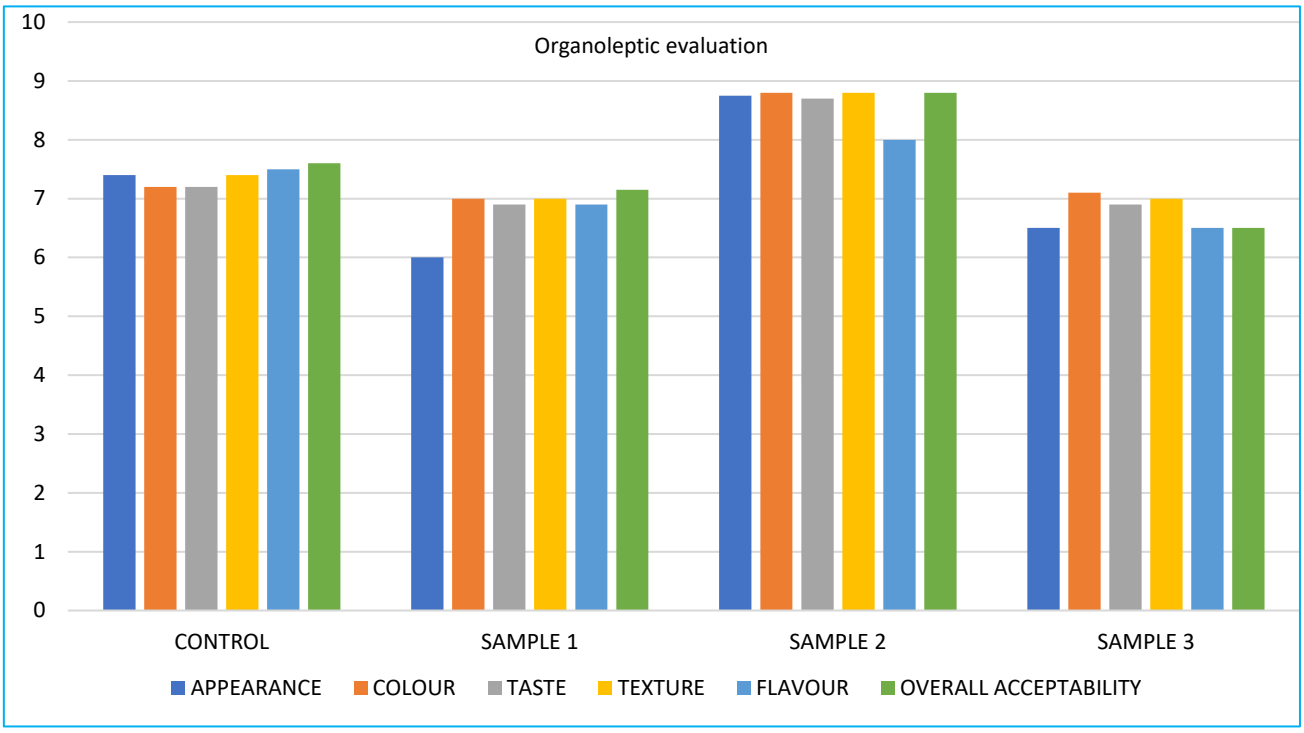

Fig 3 Sensory analysis of Khakhra incorporated with makhana

Sensory evaluation of khakhra incorporated with makhana

Sensory evaluation was done to find the acceptability of the Makhana khakhra using 9-point hedonic scale. Various characteristics like appearance, color, texture, taste, odor, and overall acceptability were scored from a rating 9 to 1. The ranks were categorized as:

- 9 – Like extremely
- 8 – Like very much
- 7 – Like moderate
- 6 – Like slightly
- 5 – Neither like nor dislike
- 4 – Dislike slightly
- 3 – Dislike moderately
- 2 – Dislike very much
- 1 – Dislike extremely

Sensory evaluation was performed by semi trained panel members using a 9-point hedonic scale and results were tabulated. Using a 9-point hedonic scale the variations were evaluated. Among the 3 variations one was selected (T_2) which got the highest score.

Statistical analysis: Statistical analysis was conducted for the data. The data obtained from khakhras are interpreted by using descriptive statistics (mean and standard deviation) and statistical inference (P. value).

Table 3 Analysis of variance for sensory attributes

Sensory attributes	P. Value	Level of significance ($p < 0.05$)
Appearance	0.01469	S*
Color	0.09218	NS
Taste	0.03386	S*
Texture	0.0448	S*
Flavor	0.18704	S*
Overall acceptability	0.04836	S*

Table 4 Nutritional composition of control and treatment 2 khakhras

Nutrients	Control khakhra percentage/100gm	Treatment 2 khakhra percentage/100gm
Energy value (Kcal / 100g)	425.18 ± 0.5	423.88 ± 0.67
Protein %	18.3 ± 0.22	20.3 ± 0.01
Fat %	9.5 ± 0.03	9.6 ± 0.09
Crude fiber %	3.7 ± 0.03	3.8 ± 0.11
Carbohydrates %	66.02 ± 0.3	64.07 ± 0.65

Values are Mean ±SD of three replicates

Nutritional composition of makhana khakhra

The developed product and best accepted product were subjected to nutrition quality analysis using standard procedures. The proximate composition for macronutrients

including energy, protein, fat, carbohydrates, and dietary fiber was estimated. Below table represents the proximate composition of Control and Treatment 2 (30% makhana powder) khakhras. The nutrients were evaluated, and the results are discussed below:

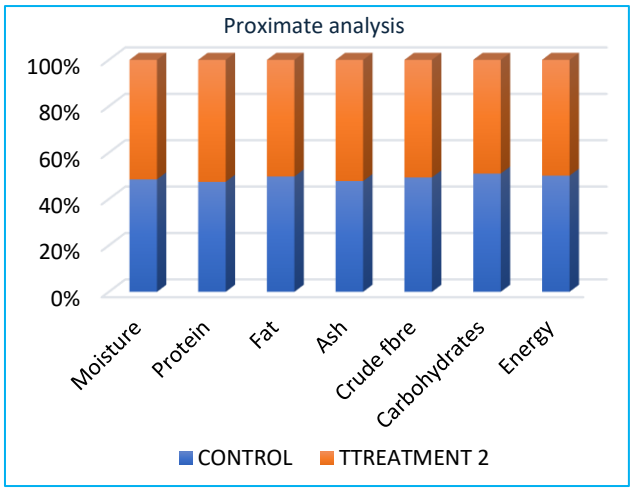

Fig 4 Proximate analysis of the Control and T_2 Khakhras

The protein content of highly acceptable Treatment 2 khakhra was found to be 20.3±0.01g/100g which was comparatively higher than the control khakhra which ranges from about 18.3±0.22g/100g. The higher protein content of the treatment 2 khakhra was due to the incorporation of the dried makhana powder. Mean of all the treatment were compared. Out of the three Treatment, Treatment 2 was best accepted for all the attributes. It was found that the chemical composition contains 423.88 Kcal of energy, 20.3% of protein, 9.6% of fat, 3.8% of fibre, and 64% of carbohydrates.

CONCLUSION

It could be concluded that the addition of makhana powder provides a nutritional packed snack product and possesses a better nutritional profile. Based on results, it could be concluded that T_2 is ideal for preparation of khakhra. The makhana-incorporated khakhras also offer a good amount of healthy fats, which are essential for our body's functions. These fats help in nutrient absorption and provide sustained energy throughout the day. By incorporating makhana powder into khakhras, we enhance their nutritional profile, making them a healthier option. Additionally, the makhana-incorporated khakhras can be an excellent choice for those who are health-conscious or looking to maintain a balanced diet. They provide a good amount of nutrients while being low in calories. This combination makes them a satisfying and guilt-free snack option. In conclusion, the makhana-incorporated khakhras offer a superior nutritional profile, including protein, fiber, minerals, and healthy fats. They can be a healthier and more nutritious alternative to regular khakhras, making them an excellent choice for those seeking a tasty and wholesome snack option. After preparation of makhana incorporated khakhra, it was packed in plastic pouches to extend shelf life of the product.

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