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Development of nutritionally enhanced vegan mayonnaise using makhana (*Euryale ferox*)

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Abstract
The growing interest in plant-based foods has encouraged the development of alternatives to conventional mayonnaise, which traditionally relies on egg yolk and a high proportion of oil. This study evaluated the use of soya milk as an egg-free base and makhana (*Euryale ferox*) powder as a plant-derived ingredient in vegan mayonnaise. Four formulations were assessed: T_0 (soya milk:vegetable oil:makhana powder, 40:60:0), T_1 (40:57:3), T_2 (40:55:5), and T_3 (40:53:7). The products were evaluated for proximate composition, titratable acidity, antioxidant activity, texture, microbiological quality, sensory acceptance, and estimated production cost. Based on the thesis master table, increasing makhana inclusion was associated with a reduction in fat from 60.89% in T_0 to 53.93% in T_3, while protein increased from 1.34% to 2.36%, dietary fibre from 0.18% to 0.22%, ash from 0.26% to 0.30%, and DPPH radical-scavenging activity from 5.52% to 26.02%. Firmness and cohesiveness also increased across the formulations. No detectable coliforms or yeast and mould were reported in any treatment, while the standard plate count ranged from 1.18×10^2 to 1.56×10^2 CFU/g. Sensory results favoured the control for overall acceptability (8.50), with T_1 close behind (8.46); T_3 received the lowest score (7.44). The estimated cost per 100 g increased from 41.05 for T_0 to 53.75 for T_3. Overall, makhana powder showed potential to improve selected compositional and functional attributes while reducing the oil proportion, although higher inclusion affected sensory acceptance and cost. The findings support further optimization, particularly around the lower inclusion level, alongside more detailed stability and shelf-life testing.

Keywords: Makhana, *Euryale ferox*, Vegan mayonnaise, Soya milk, Emulsion, Antioxidant activity, Texture, Sensory acceptance

Introduction

Mayonnaise is a semi-solid oil-in-water emulsion valued for its creamy texture, characteristic flavour, and ability to accompany a wide range of foods. Conventional formulations commonly use egg yolk to help form and stabilize the emulsion, while oil contributes substantially to the product's body and mouthfeel. The high oil content and use of egg, however, can be limiting for consumers seeking plant-based foods or avoiding egg. Developing vegan mayonnaise therefore involves more than replacing egg: the new ingredients must also support emulsion formation, consistency, flavour, and consumer acceptance.

The physical quality of mayonnaise depends on the balance between the dispersed oil phase and the aqueous phase, as well as the type of emulsifying ingredients, mixing conditions, and viscosity of the continuous phase. Changes to the formulation can alter texture and stability, so nutritional modifications need to be assessed alongside sensory and physical properties (Depree *et al.*, 2001; Liu *et al.*, 2007) [1, 2].

Soya milk is a useful plant-based ingredient because it contributes water and protein and can serve as the aqueous base of an egg-free emulsion. Soy-based products have also been investigated as alternatives in mayonnaise-style formulations (Kant *et al.*, 2015; Obatolu *et al.*, 2019) [3, 4]. The effectiveness of such systems depends on the composition of the soya milk and the processing method, and the final product must be evaluated rather than assumed to perform like an egg-based mayonnaise.

Makhana, also known as fox nut or gorgon nut, is the edible seed of *Euryale ferox*. It is cultivated in parts of South and East Asia and has a long history of use in traditional foods. Published work describes makhana as a low-fat seed containing carbohydrates, protein, minerals, and phenolic compounds; its composition varies with variety and processing (Khadatkar *et al.*, 2020; Kumar *et al.*, 2023) [5, 6]. Research has also reported antioxidant activity associated with compounds present in *E. ferox* seeds (Song *et al.*, 2011; Liaquat *et al.*, 2022) [8, 7]. In a food emulsion, finely milled seed material may contribute solids and water-binding capacity, potentially affecting consistency and the distribution of oil droplets. These possible functional effects need to be verified in the actual formulation.

The present investigation explored makhana powder as an ingredient in vegan mayonnaise prepared with soya milk. The specific objectives were to compare the formulations for physicochemical composition, an

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tioxidant activity, texture, microbiological indicators, sensory quality, and production cost, and to identify a formulation that offered a practical balance between nutritional improvement and acceptability.

Materials and Methods

Materials

Makhana, soybean seeds, refined vegetable oil, salt, sugar, and vinegar were procured from local markets in Prayagraj, Uttar Pradesh, India, as reported in the source thesis. *Soya* milk was prepared from soybean seeds and used as the plant-based aqueous phase. Other ingredients, including vinegar, salt, and sugar, were kept consistent among the treatments.

Experimental formulation

Four formulations were prepared by varying the proportions of soya milk, refined vegetable oil, and makhana powder. The treatment combinations specified in the thesis materials- and-methods table and master results table were used for this paper.

Preparation of soya milk and mayonnaise

According to the thesis procedure, soybean seeds were soaked overnight, drained and washed, cooked at approximately 112 °C for four minutes, pulverized with water, cooked again, and filtered to obtain soya milk. The milk was chilled to 4–6 °C before mayonnaise preparation. It was transferred to a beaker and blended with a hand blender for approximately 30–60 seconds. Refined oil was added gradually during blending over about 2–3 minutes. For experimental treatments, makhana powder was incorporated according to the formulation, followed by vinegar, sugar, and salt. Blending continued for a further 1–2 minutes until an emulsion formed. The prepared samples were packed and stored under refrigeration at approximately 4 °C.

Treatment	*Soya* milk (%)	Vegetable oil (%)	Makhana powder (%)
T_0 (control)	40	60	0
T_1	40	57	3
T_2	40	55	5
T_3	40	53	7

Note: the thesis abstract contains a different set of makhana levels for T_2 and T_3. To maintain consistency with the detailed treatment table and the master results table, this manuscript uses 0%, 3%, 5%, and 7% makhana powder. The formulation record should be checked against laboratory notebooks before journal submission.

Physicochemical and functional analysis

The thesis reports analysis of moisture, fat, protein, dietary fibre, carbohydrate, titratable acidity, ash, and antioxidant activity. Texture profile measurements included firmness and cohesiveness. The reported values in the master table are treated here as the observed treatment means. The thesis describes statistical evaluation using analysis of variance (ANOVA) and critical difference comparisons. Because the available report contains some inconsistencies in headings and units, this paper emphasizes the reported treatment means and avoids making additional claims about significance where the underlying statistical table is not unambiguous.

Microbiological and sensory evaluation

Microbiological assessment included standard plate count (SPC), coliform testing, and yeast and mould testing. The thesis refers to standard procedures for microbial enumeration. Sensory assessment included colour and appearance, flavour, body and texture, and overall acceptability. The sensory values are reproduced as reported in the thesis; the number and characteristics of assessors and the detailed scoring protocol were not clearly specified in the material available for this manuscript.

Cost estimation and data presentation

Production cost was reported per 100 g of product. Treatment means were organized descriptively to compare changes associated with increasing makhana powder and decreasing oil. The study is presented as a formulation-level comparison rather than a clinical or health-outcome study.

Results and Discussion

Proximate composition and titratable acidity

The results indicate that the formulation changed systematically as makhana powder increased and the proportion of oil decreased. Fat content fell from 60.89% in the control (T_0) to 57.90% in T_1, 55.92% in T_2, and 53.93% in T_3. This pattern is consistent with the formulation design, in which part of the oil was replaced by makhana powder. It is important to interpret this as a reduction in measured fat within the tested formulations, not as proof that the product is low-fat in an absolute or regulatory sense.

Protein content rose from 1.34% in T_0 to 1.78%, 2.10%, and 2.36% in T_1, T_2, and T_3, respectively. Dietary fibre increased from 0.18% to 0.22%, and ash increased from 0.26% to 0.30%. These changes suggest that makhana contributed measurable solids and nutrients to the product. Similar interest in the compositional value of makhana has been reported in studies describing its protein, mineral, and carbohydrate fractions (Khadatkar *et al.*, 2020; Kumar *et al.*, 2023) [5, 6]. The absolute fibre values in the mayonnaise remained modest, however, and should not be overstated as a high-fibre claim without reference to applicable standards.

Carbohydrate content increased from 0.52% in T_0 to 2.90% in T_1, 4.49% in T_2, and 6.12% in T_3. This trend is expected when a seed powder rich in carbohydrate is incorporated into the formulation. The reported moisture content increased slightly, from 36.96% in T_0 to 37.20% in T_3. Although the thesis abstract describes moisture as decreasing with higher makhana addition, the master table gives a small increase; this manuscript follows the numerical master table and flags the discrepancy for verification.

Titratable acidity decreased from 0.36 in T_0 to 0.35 in T_1, 0.34 in T_2, and 0.32 in T_3. Since vinegar was reportedly held constant, the change may reflect differences in the composition or buffering characteristics of the formulations, but the available data do not establish a mechanism. Acidity is relevant to both flavour and microbial control, so future work should report the analytical basis, units, pH, and storage changes together.

Antioxidant activity and texture

DPPH radical-scavenging activity increased substantially with makhana inclusion: 5.52% in T_0, 15.89% in T_1, 20.11% in T_2, and 26.02% in T_3. The trend suggests that the added makhana powder contributed compounds capable of reacting in the assay. This is broadly consistent with published work reporting phenolic constituents and antioxidant activity in *Euryale ferox* seeds (Song *et al.*, 2011; Kumar *et al.*, 2023; Liaquat *et al.*, 2022) [8, 6, 7]. Nevertheless, DPPH results are an in-vitro chemical measurement. They do not by themselves demonstrate a health benefit in people, nor do they indicate how much antioxidant activity would remain during storage or digestion.

Texture measurements changed alongside composition. Firmness increased from 12.42 N in T_0 to 14.16 N in T_1, 16.84 N in T_2, and 17.73 N in T_3. Cohesiveness rose from 2.97 in T_0 to 3.40, 3.91, and 4.38 across T_1–T_3. The higher solids content and water-binding behaviour of the powder may have contributed to the firmer, more cohesive structure, although direct evidence of the mechanism would require additional rheological or microstructural measurements.

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Table 1. Composition and functional properties of makhana mayonnaise

Parameter	T_0	T_1	T_2	T_3
Moisture (%)	36.96	37.10	37.17	37.20
Fat (%)	60.89	57.90	55.92	53.93
Protein (%)	1.34	1.78	2.10	2.36
Dietary fibre (%)	0.18	0.20	0.21	0.22
Carbohydrate (%)	0.52	2.90	4.49	6.12
Titratable acidity	0.36	0.35	0.34	0.32
Ash (%)	0.26	0.28	0.29	0.30
DPPH activity (%)	5.52	15.89	20.11	26.02

Source: master table in the supplied thesis. Values are reported treatment means; units for titratable acidity follow the thesis table and require confirmation.

Texture is central to mayonnaise quality because consumers expect a spreadable product that holds together while remaining smooth. Prior work on mayonnaise has shown that formulation and fat mimetics can affect rheological, textural, and sensory characteristics (Liu *et al.*, 2007) [2]. In the present study, the rise in firmness may be useful for structure, but it also appears to have a trade-off: T_3, the firmest and most cohesive formulation, received the lowest overall acceptability score. Optimizing a plant-based mayonnaise therefore requires a balance rather than maximizing firmness or makhana concentration alone.

Microbiological quality

The reported standard plate counts were 1.56×10^2 CFU/g for T_0, 1.18×10^2 CFU/g for T_1, 1.36×10^2 CFU/g for T_2, and 1.46×10^2 CFU/g for T_3. Coliform and yeast-and-mould tests were reported as nil for all four treatments. These results indicate that the tested samples had no detectable coliforms or yeast and mould under the reported test conditions. The SPC values were low and did not follow a simple dose-response pattern with makhana addition.

These observations should be interpreted cautiously. A single set of microbial results cannot establish shelf life or guarantee safety throughout storage. The thesis does not provide a complete time-series microbial study in the available summary. Future investigations should document sampling time, storage temperature, detection limits, replicate counts, pH, packaging conditions, and relevant food-safety criteria. This is especially important for refrigerated emulsions containing plant milk.

Sensory evaluation

The control (T_0) had the highest overall acceptability score at 8.50, closely followed by T_1 at 8.46. T_2 scored 8.18, while T_3 scored 7.44. Thus, the formulation with 3% makhana powder retained an overall score close to the control, whereas higher additions were associated with a gradual decline in acceptance. This pattern suggests that moderate incorporation may be more practical than the highest tested level.

For colour and appearance, T_2 received the highest reported score (9.00), while T_0, T_1, and T_3 were each reported at 8.00. Flavour scores were reported as 8.00 for T_0 and T_2, 7.00 for T_1, and 6.00 for T_3. Body-and-texture scores in the thesis are internally inconsistent in their ranking: the narrative states T_0 (8.16) followed by T_2 (8.34), T_1 (8.02), and T_3 (7.62), even though 8.34 is numerically higher than 8.16. These values should be checked against the original sensory table before publication. The overall acceptability ranking is clear in the report and is used as the primary sensory outcome here.

The lower acceptance of T_3 may relate to its greater firmness, more pronounced seed-powder contribution, or changes in flavour and mouthfeel. These explanations are plausible interpretations rather than directly tested causes. Sensory results should also be interpreted in light of the missing details about panel size, assessor training, scale anchors, randomization, and blinding.

Table 2. Selected texture, microbial, sensory and cost outcomes

Parameter	T_0	T_1	T_2	T_3
Firmness (N)	12.42	14.16	16.84	17.73
Cohesiveness	2.97	3.40	3.91	4.38
SPC ($\times 10^2$ CFU/g)	1.56	1.18	1.36	1.46
Coliform test	Nil	Nil	Nil	Nil
Yeast and mould	Nil	Nil	Nil	Nil
Overall acceptability	8.50	8.46	8.18	7.44
Cost per 100 g	41.05	45.27	49.51	53.75

Source: supplied thesis master table and results narrative. Cost currency was not clearly specified in the table and should be confirmed before external publication.

Cost implications and formulation choice

The reported production cost per 100 g increased from 41.05 for T_0 to 45.27 for T_1, 49.51 for T_2, and 53.75 for T_3. The increase is consistent with the addition of makhana powder and the cost structure used in the thesis, although the calculation details and currency were not supplied in the master table. A final economic comparison should include ingredient prices, processing losses, packaging, refrigeration, labour, and overheads.

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Taken together, the results show a clear formulation trade-off. T_3 produced the lowest fat content and the highest protein, fibre, ash, antioxidant activity, firmness, and cohesiveness among the tested samples. However, it also had the highest reported cost and lowest overall acceptability. T_0 was least expensive and most acceptable, but it had the highest fat content and the lowest values for several measured nutritional and functional attributes. T_1 appears to provide a useful compromise: fat was lower than the control, protein and antioxidant activity were higher, and overall acceptability remained close to T_0. On the basis of the available results, T_1 (40:57:3) can be considered a promising candidate for further optimization rather than a definitive optimum. This recommendation is based on its balance of measured attributes, not on a formal multi-criteria optimization. A follow-up study could test intermediate levels around 3–5% makhana, refine particle size, and adjust acid and seasoning levels to improve flavour and spreadability without losing the nutritional changes.

Summary

This study examined four vegan mayonnaise formulations prepared with soya milk and varying levels of makhana powder. The control contained no makhana, while T_1, T_2, and T_3 contained 3%, 5%, and 7%, respectively, according to the detailed treatment table. Across these formulations, measured fat decreased as makhana inclusion increased. Protein, dietary fibre, ash, carbohydrate, DPPH activity, firmness, and cohesiveness increased. The reported moisture values rose slightly, while titratable acidity declined.

The microbiological results showed nil detectable coliforms and yeast and mould in all treatments. Standard plate counts ranged from 1.18×10^2 to 1.56×10^2 CFU/g. Sensory evaluation favoured T_0 for overall acceptability (8.50), with T_1 very close at 8.46; acceptance decreased at higher makhana levels, reaching 7.44 in T_3. Estimated cost per 100 g rose with makhana addition, from 41.05 in T_0 to 53.75 in T_3. The overall pattern suggests that makhana can contribute to the compositional and textural profile of an egg-free mayonnaise, but increasing the amount is not automatically beneficial across all product-quality dimensions. The lower inclusion level may be a practical starting point for further development.

Conclusion

Makhana powder showed promise as an ingredient in soya-milk-based vegan mayonnaise. Under the conditions reported in the thesis, increasing makhana addition reduced fat content and increased protein, fibre, ash, DPPH activity, firmness, and cohesiveness. These changes indicate potential for nutritional and functional modification of the product. At the same time, higher makhana levels were associated with lower overall sensory acceptance and higher estimated cost.

T_1, containing 3% makhana powder in the reported formulation, offered the closest overall acceptability to the control while improving several measured attributes. It is therefore a reasonable formulation for further trials. Before commercial or journal claims are made, the original treatment ratios, sensory table, analytical units, cost currency, statistical outputs, and microbial methods should be verified. Further work should include a larger and clearly described sensory panel, replicated physicochemical analyses, emulsion stability and shelf-life testing, and a complete cost model. The present findings support the feasibility of makhana-enriched vegan mayonnaise but do not, on their own, establish health effects or commercial shelf life.

References

1. Depree JA, Savage GP. Physical and flavour stability of mayonnaise. Trends in Food Science & Technology. 2001;12(5–6):157–163.
2. Liu H, Xu XM, Guo SD. Rheological, texture and sensory properties of low-fat mayonnaise with different fat mimetics. LWT—Food Science and Technology. 2007;40(6):946–954.
3. Kant R, Broadway A. The benefits of consuming soya milk—a review. Trends in Biosciences. 2015;8(5):1159–1162.
4. Obatolu VA, Adeniyi PO. Nutritional, physical and sensory properties of soybean mayonnaise. Moor Journal of Agricultural Research. 2019;20(1).
5. Khadatkar A, Mehta CR, Gite LP. Makhana (*Euryale ferox* Salisb.): A high-valued aquatic food crop with emphasis on its agronomic management—A review. Scientia Horticulturae. 2020;261:108995.
6. Kumar MM, Goudar G, Sharma P, Vishwakarma R, Gogoi P, Mahajan A, *et al.* Differentiating the nutrient composition, in-vitro starch digestibility, individual polyphenols and antioxidant properties of raw and popped makhana (*Euryale ferox*). Journal of Food Measurement and Characterization. 2023;17(6):5828–5844.
7. Liaquat M, Pasha I, Ahsin M, Salik A. Roasted fox nuts (*Euryale ferox* L.) contain higher concentrations of phenolics, flavonoids, minerals and antioxidants and exhibit lower glycemic index in human subjects. Food Production, Processing and Nutrition. 2022;4:1.
8. Song CW, Wang SM, Zhou LL, Hou FF, Wang KJ, Han QB, Li N, Cheng YX. Isolation and identification of compounds responsible for antioxidant capacity of *Euryale ferox* seeds. Journal of Agricultural and Food Chemistry. 2011;59(4):1199–1204.
9. Ahmed D, Kumar V, Verma A, Shukla GS, Sharma M. Anti-diabetic, antioxidant and *anti*-hyperlipidemic effects of *Euryale ferox* Salisb. extract in streptozotocin-induced diabetic rats. SpringerPlus. 2015;4:315.
10. Jana BR, Idris M. Anti-aging amino acids in *Euryale ferox* (Salisb.): A review. Advances in Plants & Agriculture Research. 2018;8(1):39–43.

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