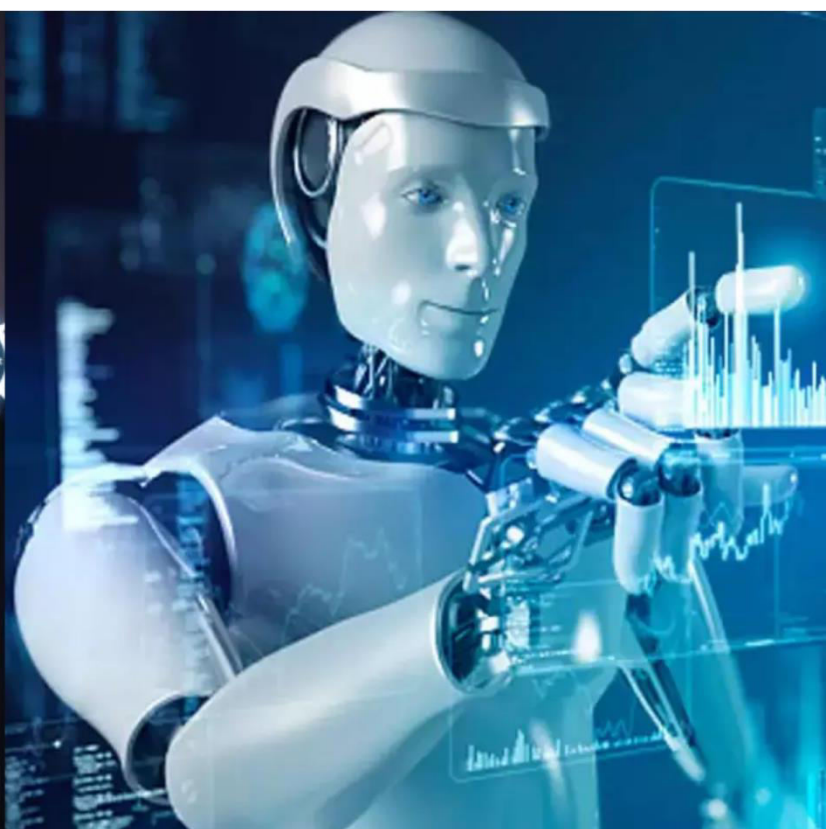




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Development and Quality Evaluation of Lotus Seed (*Nelumbo nucifera*) Vegetable Instant Soup Mix Powder: Proximate Composition, Functional Properties, Microbiological Safety, Sensory Acceptability, and Shelf Life Profile

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ABSTRACT:

Aim: To develop and evaluate an instant vegetable soup mix powder with lotus seed (*Nelumbo nucifera*) as the main functional ingredient and to determine its proximate composition, physical and functional properties (flow and reconstitution), microbiological safety, sensory acceptability and short-term storage stability.

Study Design: Experimental product development and quality assessment study.

Place and Duration of Study: Department of Food Technology and Quality Management, Padmashree Institute of Management and Sciences, Bengaluru, Karnataka, India. [duration of study: January to march 2026]

Methodology: The optimum formulation consisted of 40% dehydrated lotus seed powder, 25% of vegetables (sweet pumpkin, sweet corn, tomato, onion), 15% of maize flour as thickening agent and remaining spice, salt and sugar ingredients. Standard AOAC/FSSAI methods were used to evaluate proximate composition, powder flow behaviour (Carr's Index, Hausner Ratio), reconstitution behaviour (Water Absorption Index, Water Solubility Index), microbiological safety, sensory acceptability (9-point hedonic scale) and shelf life stability under ambient storage.

Results: The proximate analysis of the sample showed moisture ($3.29\% \pm 0.15\%$), total ash ($11.36\% \pm 0.32\%$), crude protein ($12.68\% \pm 0.41\%$), crude fat ($2.36\% \pm 0.08\%$), crude fiber ($2.03\% \pm 0.11\%$) and total carbohydrate ($70.34\% \pm 1.25\%$) which gave about 353 kcal per 100 g. Physical characterization demonstrated good flow qualities (Carr's Index 17.46%; Hausner Ratio 1.21) while the reconstitution investigations suggested efficient hydration (Water Absorption Index 20%; Water Solubility Index 4%). No *E. coli* was detected in the microbiological examination. *E. coli*, coliforms, yeast and mold, *Vibrio* spp. Sensory evaluation with 9-point hedonic scale revealed great acceptability for all qualities (mean score for overall acceptability 8.0) and product was found to sustain acceptable quality for minimum two months of ambient storage.

Conclusion: Lotus seed powder can be utilized as a nutrient rich clean label ingredient for the development of functional instant soup products with favorable nutritional, physical, microbiological and sensory characteristics suitable for ambient shelf storage.

KEYWORDS: *Lotus seed (Nelumbo nucifera); instant soup mix; proximate composition; functional properties; microbiological safety; sensory evaluation; shelf life.*

I. INTRODUCTION

The main reasons for the transition towards ready-to-eat and instant meal products in the global food sector are urbanization, longer working hours and changing customer lifestyles (Gupta, Mehta, & Verma, 2022). However, this tendency has been associated with increased consumer aversion to the high sodium, refined sugars, synthetic additives and low quality starch fillers that are prevalent in conventional convenience foods (Fellows, 2017). Food makers have therefore the double challenge to produce goods that combine ease of preparation and real nutritional content, optimally on the basis of minimally processed and recognizable ingredients.

Nelumbo nucifera, commonly known as sacred lotus, is an aquatic perennial plant of the *Nelumbonaceae* family, widespread in South East Asia, East Asia and Oceania (Sheikh, 2014). Almost all plant parts have nutritional, medical and cultural value. The rhizome is eaten as a vegetable; the leaves are used as biodegradable wrapping material and the petals for natural paints. Of them, the ripe seed is of special importance due to its unique mix of nutrients and phytochemicals (Wang & Zhang, 2010). Lotus seeds have been employed in Ayurvedic and traditional Chinese medicine for centuries to treat inflammation, metabolic disorders, dermatological conditions and digestive complaints, and some of these traditional uses have been confirmed by pharmacological studies which have shown anti-inflammatory, hypoglycemic, hepatoprotective, cardioprotective and antioxidant activity of lotus seed extracts (Chen et al., 2020; Mukherjee, Kumar, Mal, & Houghton, 2007).

Macronutrients in Lotus seeds are high in plant based protein and complex carbohydrates, but relatively low in lipids and include important minerals such as potassium, magnesium, phosphorus, iron, and zinc (Liu et al., 2017; Wu, Chen, Zhang & Wang, 2007). The embryonic plumule in the middle of the seed includes bioactive alkaloids such as neferine, liensinine and flavonoid chemicals, which provide extra antioxidant capability (Wang, Gong, Wu, & Shi, 2016). Dehydration of lotus seed into a powder form improves handling, storage stability, and transport efficiency, and the natural starch content of the powder provides an opportunity to use it as a clean label thickening agent, potentially reducing the use of chemically modified starches in food formulation (Singh, Yadav, & Mishra, 2020).

Despite these advantages, the application of lotus seed in mainstream food product development still remains limited to the traditional preparations and regional snack foods. There is a limited amount of study on the use of lotus seed powder as the primary structural ingredient in a dehydrated instant soup formulation (Bysani, Reddy, & Kumar, 2025; Shinde & Swami, 2025). Hence the present work was designed for formulation and evaluation of lotus seed based instant vegetable soup mix powder with special emphasis on proximate composition, powder flow properties, microbiological safety, sensory acceptance and storage stability.

II. MATERIALS AND METHODS

2.1 Procurement and Processing of Raw Materials

Fresh ripe seeds of *Nelumbo nucifera* were purchased from wholesale markets of Bengaluru, Karnataka, India. The outer shells were broken by hand and the bitter green plumule of each seed was taken out. The remaining white seed kernels were rinsed in clean water to eliminate dust and field debris. These were then dried in a hot air oven at 60-65°C for 6-8 h, until the moisture content was reduced to below 10%. The seeds were dried and lightly roasted at 120 °C for 10 min to produce taste. The roasted material was pulverized in mixer grinder and then passed through a 60 mesh screen to give a homogeneous particle size.

Vegetables like (sweet pumpkin, onion, tomato and sweet corn) were washed, trimmed, hand chopped and dried individually by hot air oven and sun drying at 55-60°C for 10-12 hours. The coriander was dried at lower temperature (40-50°C) for 3-5 hours to safe guard the volatile oils. Each dried vegetable was ground individually and preserved in sealed glass jars. We got corn flour, iodised salt, whole black pepper from local sources.

2.2 Product formulation standardization

After multiple trials, a formulation was chosen that achieved a compromise between acceptable flavor and nutritional adequacy (Table 1). It was made with 40% lotus seed powder, 25% dehydrated vegetable blend, 15% corn flour, 5% iodised salt, 5% spice mix and the rest of the proportion being sugar and other structural ingredients. All materials were weighed on digital balance, combined in industrial mixer, sieved for homogeneity and packed promptly in moisture proof, multi layer pouches.

Table.1. Formulation composition and role of each ingredient

Ingredient	Composition (%)	Role in formulation
Lotus seed powder	40%	Main functional base; protein and mineral source; natural thickener
Vegetable powders / flakes (tomato, pumpkin, corn, onion)	25%	Colour, taste, vitamins, and antioxidants
Corn flour	15%	Supplementary thickening agent for desired consistency
Salt	5%	Primary seasoning and flavour enhancer
Spices and herbs (black pepper, garlic, coriander)	5%	Pungency, warmth, and aroma
Sugar	2%	Mild taste balancing

2.3 Physical and Rheological Characterization of Powder

The bulk density (BD) and tap density (TD) were measured by the usual measuring cylinder method. The soup mix was added slowly to a 100 ml measuring cylinder using a 20 g sample and the initial uncompacted volume was measured. The cylinder was then tapped on a flat surface until no further change in volume occurred and the final compacted volume was recorded. The powder flowability was evaluated using Carr's Index and Hausner Ratio calculated from these values.

The rehydration behavior was determined by calculating the Water Absorption Index (WAI) and Water Solubility Index (WSI). 1 g powder was combined with 10 ml distilled water in a centrifuge tube and allowed to hydrate for 30 min and centrifuged at 3000 rpm for 10 min. Pour the supernatant into a pre weighed plate and dry at 105°C. The WAI was determined from the wet residual solids and the WSI from the dried solids in the supernatant.

2.4 Chemical and Proximate Composition Analysis

Proximate values were determined in triplicate by established AOAC and FSSAI techniques (AOAC, 2023; FSSAI, 2021). Moisture was determined by decrease in weight after drying in a hot air oven at 105°C to a constant weight. The ash composition was assessed by incineration of a 2 g sample in a muffle furnace at 550 °C for 4–6 h until a homogenous grey white ash remained. Protein was determined by the Kjeldahl technique ($N \times 6.25$). Fat was extracted using petroleum ether using a Soxhlet system. Fiber was estimated by acid and alkali digestion followed by ashing. Carbohydrate content was determined by difference.

2.5 Microbiological Safety Evaluation

Standard plate counting was performed on selective growth media to confirm compliance with food safety regulations. Serial dilutions were prepared by diluting 10 g of the soup mix powder in 90 ml of sterile saline. Total live bacteria were enumerated on Nutrient Agar after incubation for 24-48 h at 37°C. The coliforms and enteric bacteria were enumerated by utilizing Eosin Methylene Blue (EMB) and MacConkey agar. Identification of *Vibrio* species was carried out by Thiosulfate citrate bile salts sucrose (TCBS) agar. Yeast and mold were determined using Potato Dextrose Agar (PDA) at 25 °C for 48–72 h.

2.6 Sensory Evaluation and Shelf-Life Testing

The soup was evaluated by semi trained panel of departmental faculty (PIMS) with the help of 9 point hedonic scale from 9 (like highly) to 1 (dislike excessively) (Lawless & Heymann, 2010). Samples were prepared by boiling 20 g powder in 200 ml water for 3 min and delivered warm in randomly coded cups under constant lighting conditions. The panelists were asked to score appearance, colour, scent, taste, consistency, mouthfeel and overall liking. To test shelf life, samples were stored in sealed, multi layer pouches at room temperature (25–30°C, 65% RH) for 90 days and were tested at intervals for moisture, caking and sensory alterations.

III. RESULTS AND DISCUSSION

3.1 Chemical Proximate Attributes and Nutritional Implication

The proximate composition of the generated soup mix powder is presented in Table 2 and Figure 1. The moisture content ($3.29\% \pm 0.15\%$) was far below the 10% range normally advised for dry instant powders, a level that is expected to lower water activity and hence limit enzymatic breakdown and microbiological growth. The total ash concentration was $11.36\% \pm 0.32\%$ which implies a mineral dense matrix, most probably due to the potassium, magnesium and phosphorus naturally contained in lotus seed, with mineral contributions from pumpkin powder (Wu et al., 2007).

Crude protein content ($12.68\% \pm 0.41\%$) was significantly greater than the 2-3% commonly reported for commercial starch based instant soups (Mudgil, Barak, & Khatkar, 2014) indicating the usefulness of the formulation as a more nutritionally complete option. The crude fat level was fairly low ($2.36\% \pm 0.08\%$) which is in accordance with the consumer preference for low fat convenience items. Carbohydrates were the largest nutrient fraction ($70.34\% \pm 1.25\%$), mainly from native starch of lotus seed and corn flour, and the energy value was approximately 353 kcal per 100 g. The crude fiber content ($2.03\% \pm 0.11\%$) contributes modestly but functionally useful for gastrointestinal health and satiety (Singh, Yadav, & Mishra, 2020).

Table.2. Proximate chemical composition of the instant lotus seed soup mix

Proximate parameter	Mean value (% w/w) $\pm$ SD
Moisture content	3.29 ± 0.15
Total ash content	11.36 ± 0.32
Crude protein ($N \times 6.25$)	12.68 ± 0.41
Crude fat / lipids	2.36 ± 0.08
Crude dietary fibre	2.03 ± 0.11
Available total carbohydrates	70.34 ± 1.25

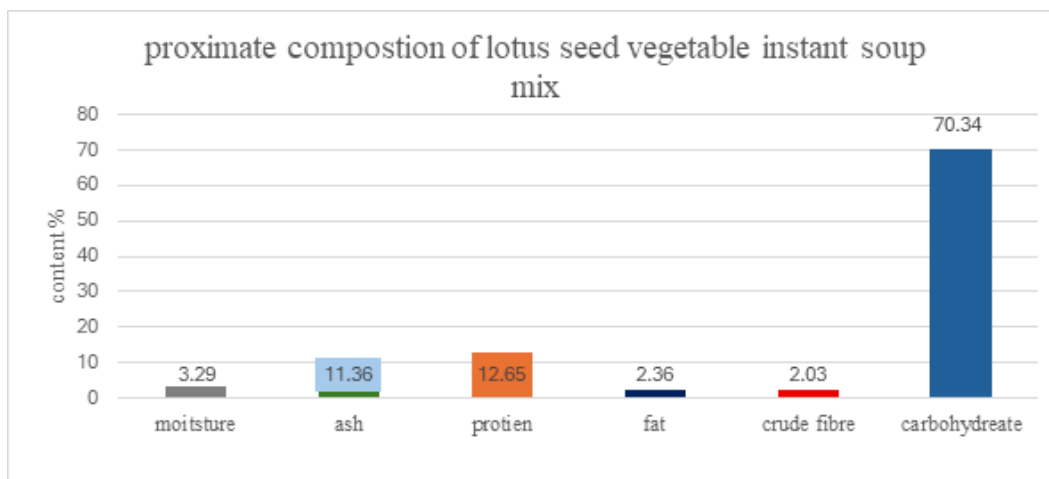


Fig.1. Proximate composition of the lotus seed soup mix powder (error bars show $\pm$ SD).

3.2 Rheological and Flow Performance of Powder Matrix

Powder flow behaviour is a key factor in determining packaging efficiency, storage stability and appropriateness for automated industrial processing. Table 3 and Figure 2 show a summary of the formulation's physical and rheological properties. The bulk density (0.52 g/ml) and tap density (0.63 g/ml) indicated a balanced particle packing configuration suitable for volumetric packaging efficiencies.

The Carr's Index (17.46%) and Hausner Ratio (1.21) were in the range that is normally considered to indicate fair to good flow (Carr's Index 15-20%; Hausner Ratio 1.20-1.25) (Sharma & Gujral, 2014), indicating that the powder should

flow consistently through industrial filling hoppers with little risk of bridging or caking. The water absorption index (20%) and water solubility index (4%) showed rapid hydration and good dispersibility in hot water compared to other seed derived flours (Zhou et al., 2015).

Table.3. Physical, flow, and reconstitution behaviour of the soup powder matrix.

Physical / rheological parameter	Value
Bulk density	0.52 g/ml
Tap density	0.63 g/ml
Carr's Index	17.46%
Hausner Ratio	1.21
Water Solubility Index (WSI)	4.00%
Water Absorption Index (WAI)	20.00%

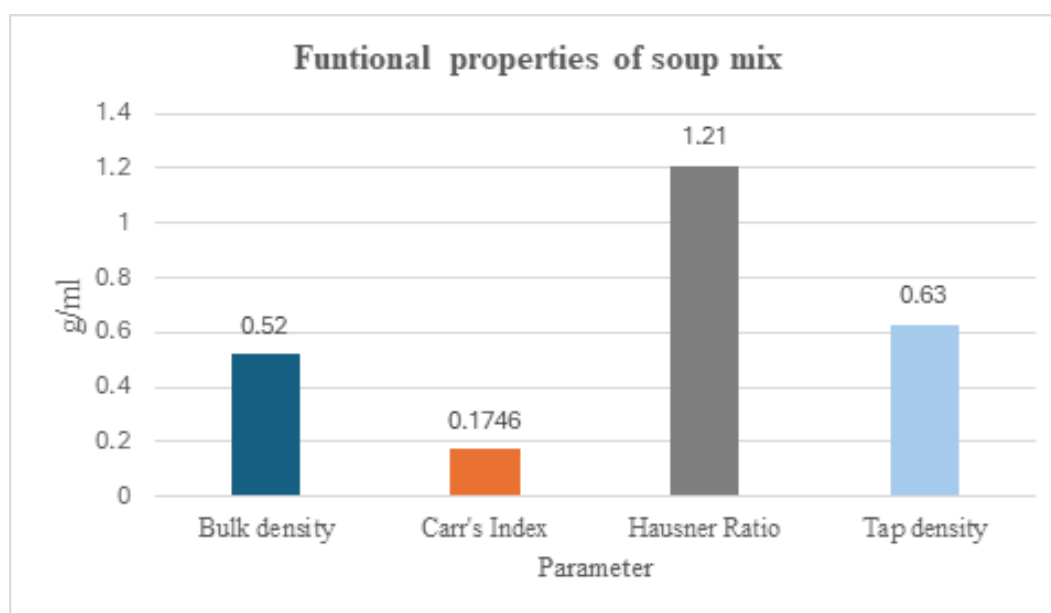


Fig.2. Physical and rheological properties of the soup powder matrix.

3.3 Microbiological Safety Assurance

Microbial analysis (Table 4) revealed that the products complied with standard food safety requirements. Total plate counts were within acceptable values and neither coliforms nor *Escherichia coli* were identified in EMB or MacConkey agar. No yeast, mold or *Vibrio* species were found on TCBS and PDA plates as well. This microbiological stability is probably due to a combination of variables including effective dehydration, appropriate thermal roasting, low water activity, and the inherent antibacterial activities of garlic, onion, and black pepper (AOAC, 2023; FSSAI, 2021).

Table.4. Microbiological safety analysis of the soup powder

Test parameter	Growth medium used	Observation	Status
Total Plate Count (TPC)	Nutrient Agar	Within acceptable limits	Safe
Coliform bacteria	MacConkey Agar	Absent / no growth	Safe
<i>Escherichia coli</i>	EMB agar	Absent / no growth	Safe
Yeast and mold count	Potato Dextrose Agar	Not detected	Safe
<i>Vibrio</i> species	TCBS Agar	Absent / no growth	Safe

Photographic documentation of the plate assays (Figures 3–7) is provided below in support of the microbiological safety findings summarised in Table 4.



Fig.3. Nutrient Agar (NA) plate for Total Plate Count Only a small number of microbial colonies (3–4) were observed, within an acceptable level and indicating good microbiological quality.



Fig.4. Potato Dextrose Agar (PDA) plate for yeast and mold count. No fungal colonies were observed, indicating the absence of fungal contamination.



Fig.5. Eosin Methylene Blue (EMB) agar plate for *Escherichia coli*. No characteristic colonies were observed, indicating the absence of coliform contamination.



Fig. 6. MacConkey agar plate for coliform bacteria. No growth was observed, confirming the sample was microbiologically safe.



Fig. 7. Thiosulfate Citrate Bile Salts Sucrose (TCBS) agar plate for *Vibrio* species. No colonies were observed, indicating the absence of *Vibrio* organisms.

3.4 Sensory Profile and Consumer Acceptability

Sensory evaluation results (Table 5, Figure 8) showed great customer approval of all evaluated qualities. The hue, the panellists said, was appealing and came organically from the ingredients of pumpkin and tomato, so that no synthetic colourings were used. The spice blend was balanced by the mild distinctive taste of the lotus seed base. The combined starch content of lotus seed and corn flour created a smooth even texture without any evident separation. Overall acceptability scores came into the highest tier of the hedonic scale indicating good commercial prospects of this formulation (Lawless & Heymann, 2010; Bysani, Reddy, & Kumar, 2025).

Table.5. Sensory profile and consumer acceptability panel scores of the soup.

Sensory attribute	Panel mean score	Descriptive quality level
Appearance	8.4	Highly attractive and clean
Colour	8.0	Natural, appetising vegetable tint
Aroma	7.5	Pleasant, spicy aroma
Taste	8.0	Balanced, highly acceptable flavour
Texture & smoothness	8.0	Very smooth mouthfeel
Consistency	7.5	Good thickness, uniform dispersion
Overall acceptability	8.0	Highly acceptable consumer response

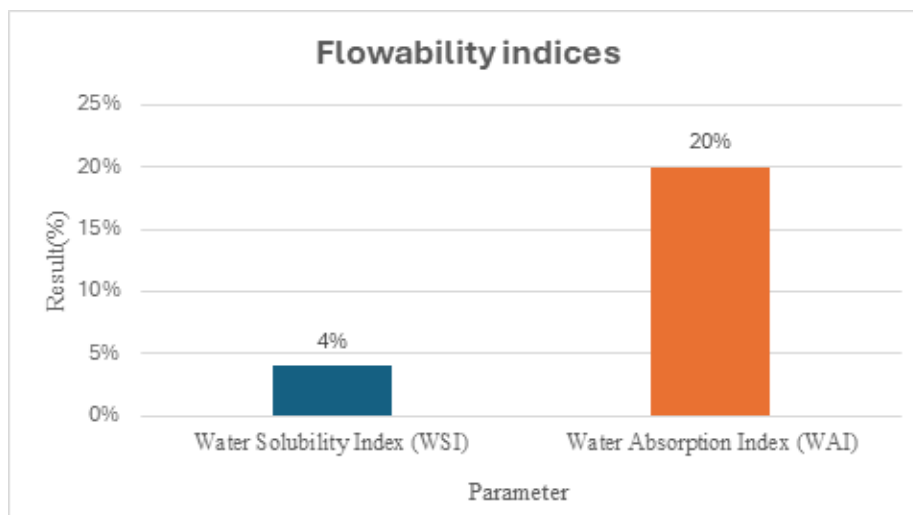


Fig.8. Sensory attribute scores of the lotus seed soup mix.

3.5 Storage and Shelf-Life Progression

The formulation showed high physical and chemical stability in a storage trial at ambient conditions (Table 6, Figure 9). Moisture uptake was minimized by the moisture resistant qualities of the laminated pouches and no caking or clumping was detected. Sensory qualities such as flavour, fragrance and colour exhibited only minor reduction throughout storage term, keeping within acceptable standards. These results show a stable shelf life of at least two months under ambient circumstances, which should be sufficient for regular retail distribution timeframes (Shinde & Swami, 2025).

Table.6. Storage and shelf-life trial of the lotus seed soup mix powder.

Storage interval	Moisture (%)	Aroma status	Visual mold check	Overall status
Day 0	3.29	Fresh, strong	Absent	Excellent
Month 1	3.32	Fresh, stable	Absent	Good / fully acceptable
Month 2	3.38	Acceptable	Absent	Stable / acceptable

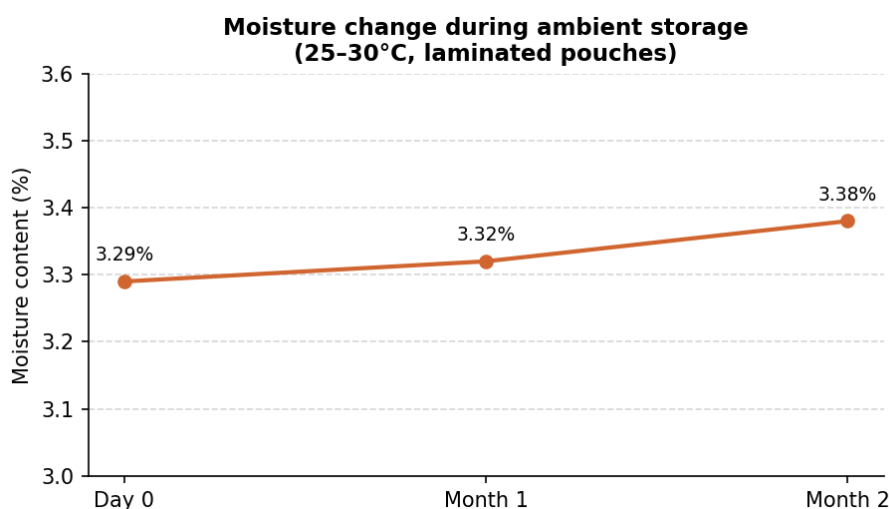


Fig.9. Moisture changes during ambient storage (25–30°C, laminated pouches).

3.6 Product Photographs

Representative images of the produced product in the dry powder form and after reconstitution are shown in Figures 10 and 11, demonstrating the natural colour and look achieved without the use of synthetic additives.



Fig.10. Reconstituted lotus seed vegetable soup



Fig.11. Lotus seed vegetable instant soup mix powder

IV. CONCLUSION

This work was concerned with the development of the standardized formulation and processing technique for the nutritionally enriched instant vegetable soup mix powder based on lotus seed (*Nelumbo nucifera*) that is shelf-stable. Proximate analysis showed that the plant protein content was good (12.68%) and the mineral density was good (11.36% ash), but the fat content was poor. The powder had good flow properties for industrial handling and reconstituted quickly in hot water. The product was microbiologically safe and the sensory study showed great consumer acceptance of all the evaluated qualities. Overall, these results support the potential use of lotus seed powder as a nutrient dense, clean label ingredient in functional instant soup applications.

Further studies should be directed towards the characterization of the retention of specific bioactive compounds such as flavonoids and polyphenols using sophisticated chromatographic techniques. Alternative packaging procedures such as nitrogen flushing should be examined to extend shelf life beyond six months. Clinical trials should be conducted to validate possible therapeutic effects such as glycemic modulation and antioxidant activity.

V. ACKNOWLEDGEMENTS

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

The Vishnuvarjala Anusha author planned the project, conducted the formulation trials and laboratory analysis, produced the first draft of the publication. and Varun N, Vaidurya BN conducted the physicochemical, microbiological, and Varun N, Vaidurya BN sensorial analyses and helped in the compilation of results. Author NAGAMANI (GUIDE) designed the study, was involved in the study design, and reviewed the manuscript. All writers read and approved the final manuscript.

CONSENT

All panelists who took part in the sensory evaluation gave their informed consent to participate prior to tasting the product.

DEFINITIONS, ACRONYMS, ABBREVIATIONS

AOAC: Association of Official Analytical Chemists. **FSSAI**: Food Safety and Standards Authority of India. **WAI**: Water Absorption Index. **WSI**: Water Solubility Index. **TPC**: Total Plate Count. **EMB**: Eosin Methylene Blue (agar). **TCBS**: Thiosulfate Citrate Bile Salts Sucrose (agar). **PDA**: Potato Dextrose Agar. **RH**: Relative Humidity.

REFERENCES

1. Acharya, C. V. K., & Srikanth, K. (2014). Second generation biofuels from *Nelumbo nucifera* (lotus) seeds. International Journal of Engineering Development and Research (IJEDR), 2(4), 3693–3696.
2. AOAC International. (2023). *Official methods of analysis* (22nd ed.). Association of Official Analytical Chemists.
3. Bysani, P. K., Reddy, S. S., & Kumar, P. R. (2025). Value addition of lotus seed flour in food products: Development and quality evaluation of noodles. Food Research Journal, 6(2), 58–64.
4. Chen, Y., Huang, B., He, J., Han, L., Zhan, Y., & Wang, Y. (2020). Bioactive compounds of lotus seeds and their antioxidant, anti-inflammatory and antimicrobial properties. Journal of Functional Foods, 68, 103890. <https://doi.org/10.1016/j.jff.2020.103890>
5. Fellows, P. J. (2017). *Food processing technology: Principles and practice* (4th ed.). Woodhead Publishing, Elsevier.
6. Food Safety and Standards Authority of India (FSSAI). (2021). *Manual of methods of analysis of foods*. New Delhi: FSSAI.
7. Gupta, R., Mehta, S., & Verma, M. (2022). Plant-based functional ingredients in value added food product development. International Journal of Food Science and Nutrition, 73(5), 621–633.
8. Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: Principles and practices* (2nd ed.). Springer.
9. Liu, Y., Ma, S., Ibrahim, S. A., Li, E., Huang, W., & Liu, G. (2017). Nutritional composition and protein quality evaluation of lotus seeds. Food Chemistry, 221, 311–317. <https://doi.org/10.1016/j.foodchem.2016.10.105>
10. Mudgil, D., Barak, S., & Khatkar, B. S. (2014). Functional properties of plant-based flours and their application in food products. Journal of Food Science and Technology.
11. Mukherjee, P. K., Kumar, V., Mal, M., & Houghton, P. J. (2007). Acetylcholinesterase inhibitors from plants. Phytomedicine, 14(4), 289–300. <https://doi.org/10.1016/j.phymed.2007.02.002>
12. Patel, D., & Rao, P. S. (2021). Functional properties and food applications of plant seed powders in food product development. Journal of Food Processing and Preservation, 45(4), e15312.
13. Sharma, R., & Gujral, H. S. (2014). Antioxidant potential, nutritional quality and functional properties of lotus seed flour. Journal of Food Science and Technology, 51(11), 3196–3203. <https://doi.org/10.1007/s13197-012-0824-0>
14. Sheikh, S. A. (2014). Ethno-medicinal uses and pharmacological activities of lotus (*Nelumbo nucifera*). Journal of Medicinal Plants Studies, 2(6), 42–46.

15. Shinde, R. S., & Swami, S. B. (2025). Comprehensive review on various soup premixes and its functional properties related to human health. *International Journal of Food and Fermentation Technology*, 15(2), 519–533.
16. Singh, K., Yadav, P., & Mishra, S. (2020). Functional and technological properties of lotus seed powder in food formulations. *International Journal of Food Technology and Nutrition*, 5(2), 88–95.
17. Wang, Q., & Zhang, X. (2010). Lotus seed (*Nelumbo nucifera* Gaertn.): Nutritional composition and health benefits. *Journal of Food Science and Nutrition*, 50(4), 321–328.
18. Wang, Q., Gong, Q., Wu, Q., & Shi, J. (2016). Antioxidant and neuroprotective activities of lotus seed bioactive components. *Journal of Agricultural and Food Chemistry*, 64(3), 716–724. <https://doi.org/10.1021/acs.jafc.5b05237>
19. Wu, Q., Chen, Y., Zhang, M., & Wang, Y. (2007). Mineral composition and nutritional evaluation of lotus seeds. *Food Chemistry*, 104(1), 256–261. <https://doi.org/10.1016/j.foodchem.2006.11.043>
20. Zhou, T., Luo, S., Xu, J., & Wang, J. (2015). Functional properties of lotus seed flour and its application in food products. *Journal of Food Processing and Preservation*, 39(6), 2472–2480. <https://doi.org/10.1111/jfpp.12493>



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