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Development and quality evaluation of an instant mushroom soup premix formulated with oyster mushroom (*Pleurotus sajor-caju*), corn starch and soya milk powder

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Abstract
Oyster mushroom (*Pleurotus sajor-caju*) is a nutritionally valuable but under-utilised crop whose short shelf life and limited consumer demand often lead to distress sales for growers. Converting the mushroom into a shelf-stable, value-added product such as an instant soup premix offers one route to improving its market potential while broadening the range of convenient, nutritionally enriched foods available to consumers. This study was undertaken to characterise the raw materials, standardise and optimise the formulation of a mushroom soup premix, and evaluate its physicochemical, nutritional, microbiological and storage characteristics. Mushroom powder, corn starch and soya milk powder were analysed for proximate composition and particle size distribution, and premix formulations were optimised for mushroom powder and corn starch content (30-45% and 15-30%, respectively) using a mixture-design approach with soya milk powder and spices held constant at 20% each. Formulations were evaluated for sensory attributes on a 9-point hedonic scale and for viscosity. The optimised formulation, containing approximately 44.72% mushroom powder and 15.27% corn starch, gave the highest overall desirability (0.721) and the best sensory scores. The optimised premix contained 18.45% protein, 8.12% fibre, 1.68% fat and provided 328.88 kcal/100 g, with a pH of 6.32, viscosity of 214.75 cP, bulk density of 0.61 g/mL, water absorption capacity of 3.18 g/g and rehydration ratio of 3.42. During 90 days of ambient storage in laminated aluminium pouches, moisture, titratable acidity and microbial counts increased gradually but remained within acceptable limits, while sensory scores declined only marginally, remaining acceptable throughout. The results indicate that oyster mushroom can be successfully incorporated into a nutritionally enriched, microbiologically safe and sensorially acceptable instant soup premix with good storage stability, offering a viable value-addition avenue for the mushroom industry.

Keywords: Oyster mushroom, *Pleurotus sajor-caju*, soup premix, value addition, mixture design, shelf-life study

Introduction

Nutritional security is an increasingly pressing challenge in the face of a growing world population, and alternative sources of nutritious food are needed to address malnutrition. Mushrooms have long played a role in meeting this need. Many cultures have consumed mushrooms for centuries, valuing them for their sensory appeal and culinary versatility. Mushrooms are fleshy, spore-bearing macrofungi with a distinct sporocarp large enough to be seen and harvested by hand, and their fruiting bodies may develop above ground (epigeous) or below ground (hypogeous). According to the National Horticultural Board of India, national mushroom production was estimated at 236,000 MT in 2021 [17]-22, of which oyster mushroom accounted for around 16% (Raman *et al.*, 2018) [22].

The oyster mushroom (Pleurotus sp.), known in India as 'Dhingri', is simple to cultivate and nutritionally rewarding (Gupta, 2021) [17]. It belongs to the family Agaricaceae and class Basidiomycetes and is the third most widely cultivated mushroom in the world. Depending on the species, its fruiting bodies show shell-, fan- or spatula-like shapes in colours ranging from white and cream to grey, yellow, pink or light brown. Oyster mushroom is regarded as one of the best substrates for producing protein-rich food from agricultural wastes without composting, typically growing over 6-8 months at 20-30°C and 57-70% relative humidity through the stages of substrate preparation, spawning, cropping and harvesting.

Nutritionally, oyster mushroom is comparable to other edible mushrooms such as button, shiitake or paddy straw mushroom. It is rich in vitamin B-complex and vitamin C, contains 1.6-2.5% protein, and supplies calcium, potassium, sodium, phosphorus and iron, along with niacin at roughly ten times the level found in common vegetables (National Horticultural Board, 2021 [17]-22). It also has a biological efficiency of approximately 100% but can be stored under ambient conditions for only about 24 hours (Torres-Martínez *et al.*, 2022) [28]. Despite these benefits, consumer demand for fresh oyster mushroom remains limited, and growers frequently face distress sales due to its short shelf life and inadequate storage infrastructure. Developing value-added oyster mushroom products is therefore seen as a practical way to expand demand, support grower incomes, and add nutritional value to consumer diets (Torres-Martínez *et al.*, 2022) [28]. Soup is one promising outlet for such value addition.

Soup is among the oldest and simplest forms of cookery, prepared by extracting flavour from meat or vegetables in stock or boiling water to form a broth. Soups are broadly classified as thick or thin (clear) soups based on texture, with thick soups further distinguished by their thickening agent — purées (starch-thickened vegetable soups), bisques

(cream-thickened puréed shellfish or vegetables), cream soups (thickened with béchamel sauce) and veloutés (thickened with egg, butter and cream). Commercial soup gained popularity with the advent of canning in the nineteenth century and today spans condensed, ready-to-eat and dry mix formats. Dry soup mixes, reconstituted with hot water before consumption, offer particular advantages: protection from enzymatic and oxidative spoilage, flavour stability at room temperature for 6-12 months, rapid preparation for households, hotels, hospitals, restaurants, institutions and military rations, and light weight for transport and year-round availability. Soup manufacturing remains a rapidly growing category worldwide, driven by demand for products that combine homemade taste with ready-to-eat convenience.

Mushrooms are increasingly regarded as next-generation healthy food components valued for their low-fat content, high-quality protein, dietary fibre and nutraceutical compounds (Das *et al.*, 2021) [3], and the oyster mushroom genus Pleurotus comprising species such as *P. ostreatus, P. florida, P. eryngii, P. cystidiosus, P. flabellatus, P. cornucopiae and P. sajor-caju* (Ram, 2007) [21] is among the most widely cultivated. *P. sajor-caju* (Fr.) Singer, first documented growing on Euphorbia royleana in the Himalayan foothills and later cultivated artificially on paddy straw and banana pseudostems (Jandaik, 1974) [9], is prized for its taste and flavour and can colonise unsterilised plant residues (Rangaswami *et al.*, 1975) [24]. Nutritionally, oyster mushroom powder is rich in vitamin C and B-complex vitamins, contains 1.6-2.5% protein and appreciable mineral content (Nongthombam *et al.*, 2021) [18], and can be readily produced from inexpensive agro-industrial waste substrates (Yang *et al.*, 2016) [29].

Several value-added oyster mushroom products have been reported, including ready-to-eat mushroom ketchup, nuggets, papad, biscuits, soup powder and fortified wheat flour (Thakur, 2018) [27], though most have yet to achieve widespread acceptance in the Indian market. Priyadarsini and Mishra (2020) [20] prepared a soup powder from dried mushroom, milk powder and corn flour and a ketchup from mushroom paste, recommending laminated aluminium pouches for the soup powder. Incorporation of P. sajor-caju powder has been shown to raise moisture, protein, viscosity, fat, ash and fibre content and improve acceptability in herbal seasoning (Bahri & Wan Rosli, 2016) [1], and to improve water absorption, dough properties and protein content when blended into bread flour at up to 6% (Majeed *et al.*, 2021) [14].

Instant soup premixes based on oyster mushroom and other functional ingredients have also been reported directly. Srivastava, Attri and Verma (2019) [25] standardised an oyster mushroom soup premix (20% mushroom powder, 40% corn flour, 25% milk powder and spices) that achieved a sensory score of 7.69 and provided 11.79 g protein, 3.54 g crude fibre and 314.65 kcal per 100 g. Singh, Ghosh and Patil (2003) similarly combined whey solids with mushroom powder to raise the protein content of a soup powder while retaining acceptable reconstitution properties, and Bugle *et al.* (2022) and Islam *et al.* (2018) [2, 7] demonstrated that yam-drumstick-roselle and fish-protein instant soup mixes, respectively, could be optimised for nutritional and sensory quality using similar formulation approaches. More recently, Pamalka *et al.* (2026) developed a vegan instant oyster mushroom soup powder enriched with moringa, mung bean and pumpkin that provided 16.3% protein and 287 kcal/100 g while keeping total aerobic plate counts below 10^5 CFU/g, underscoring the continuing interest in nutritionally enriched, microbiologically safe mushroom-based soup products.

Despite this body of work, comparatively few studies have systematically optimised the ratio of mushroom powder to a starch-based thickener using a formal mixture-design approach, or have coupled such optimisation with a documented storage study of the finished premix. Against this background, the present study was undertaken with the following objectives: (i) to characterise the raw materials used in the formulation; (ii) to standardise and optimise the formulation of a mushroom soup premix using mushroom powder, corn starch and soya milk powder; and (iii) to characterise the physicochemical, nutritional, microbiological, sensory and storage properties of the developed premix.

Materials and Methods

1. Procurement of raw materials

Mushroom powder was procured from the Department of Plant Pathology, B. A. College of Agriculture, Anand Agricultural University (AAU), Anand. Other raw materials required for the preparation of the mushroom soup premix like soya milk powder, corn starch, sugar, salt, black pepper, oregano, chilli flakes, onion powder and garlic powder were procured from the local market. All raw materials were of food-grade quality and were stored under appropriate conditions until use.

2. Preparation of mushroom powder

Fresh Pleurotus mushrooms were cleaned, sliced uniformly and dried in a hot-air tray dryer at 55 ± 2°C until a safe moisture level was reached. The dried slices were cooled to room temperature and ground into a fine powder using a grinder. The powder was packed in airtight containers and stored under dry conditions for further use.

3. Standardisation and optimisation of the formulation

Preliminary trials were carried out using mushroom powder, corn starch and soya milk powder in the range of 30-40% along with a fixed spice mix; ingredients were accurately weighed, blended to a uniform mixture, packed as a 100 g premix in airtight containers, and evaluated sensorially to narrow the working range for subsequent optimisation.

Formulation optimisation was carried out using a D-Optimal Mixture Design (Design-Expert version 10.0.3), with mushroom powder (A) and corn flour (B) as independent variables and soya milk powder and spices held constant at 20% each. Colour and appearance, flavour, consistency, after-taste and overall acceptability, together with instrumental viscosity, were the response variables. The experimental range of each factor is shown in Table 1, and the resulting thirteen-run experimental design is shown in Table 2.

Table 1: Range of independent variables used for formulation optimisation

Code	Variable	Low (%)	High (%)
A	Mushroom powder	30	45
B	Corn flour	15	30
C	Soya milk powder	20	20
D	Spices	20	20

Table 2: Experimental design (D-Optimal Mixture Design) for premix formulation

Run	Mushroom powder (%)	Corn flour (%)	Soya milk powder (%)	Spices (%)
1	30.00	30.00	20.00	20.00
2	37.50	22.50	20.00	20.00
3	35.00	25.00	20.00	20.00
4	30.00	30.00	20.00	20.00
5	40.00	20.00	20.00	20.00
6	45.00	15.00	20.00	20.00
7	33.75	26.25	20.00	20.00
8	37.50	22.50	20.00	20.00
9	45.00	15.00	20.00	20.00
10	30.00	30.00	20.00	20.00
11	37.50	22.50	20.00	20.00
12	41.25	18.75	20.00	20.00
13	45.00	15.00	20.00	20.00

4. Chemical analysis

4.1 Proximate analysis

Moisture content was determined by drying a 5 g sample at 100 ± 5°C in a hot-air oven to constant weight and calculating the loss on drying: Moisture (%) = $[(W_1 - W_2)/W] \times 100$, where W is the sample weight, W_1 is the weight of dish and sample before drying, and W_2 is the weight after drying.

Crude fat was estimated using a semi-automatic Soxhlet apparatus, extracting 2-3 g of sample with petroleum ether and calculating fat content as Crude fat (%) = $(W_2 - W_1)/W \times 100$, where W_1 and W_2 are the weights of the empty flask and the flask with extracted fat, respectively.

Crude fibre was determined using a Fibra-Plus instrument by sequential acid (1.25% H_2SO_4) and alkali (1.25% NaOH) digestion of about 2 g of defatted sample, followed by ashing, and calculated as Crude fibre (%) = $(W_2 - W_1)/W \times 100$, where W_1 and W_2 are the crucible weights before and after ashing.

Protein content was estimated by the Kjeldahl method. A 4 g sample was digested with a potassium sulphate-copper sulphate catalyst mixture (5:1) in concentrated sulphuric acid until clear, and the liberated ammonia was distilled into 4% boric acid and titrated against 0.1 N HCl using a mixed indicator (methyl red-bromocresol green). Nitrogen (%) was calculated as $(T - B) \times N \times 14 \times 100/ (W \times 1000)$, where T is the titre value, B the blank reading, N the normality of HCl and W the sample weight; protein content was obtained by multiplying nitrogen content by 6.25.

Total ash was determined by igniting about 1 g of sample in a muffle furnace at 550°C to constant weight, and calculated as Ash (%) = $(W_2 - W_1)/W \times 100$, where W_1 and W_2 are the crucible weights before and after ashing.

Carbohydrate content was estimated by difference: Carbohydrate (%) = 100 − (moisture + crude fat + protein + ash).

4.2 pH

The pH of reconstituted soup samples was measured using a microprocessor-based digital pH meter (Model 102, ESICO International), standardised against buffers of pH 5.0, 7.0 and 8.5 before each use. Sample temperature was also recorded to account for its influence on pH.

4.3 Viscosity

Viscosity was measured using a Brookfield DV-II+ Pro viscometer (Tek Instruments, Vadodara) fitted with an LV spindle (S63) operated at 3, 12, 30 and 60 rpm (Swami *et al*., 2013) [26]. Measurements were made at 40 ± 0.5°C and expressed in centipoise (cP).

4.4 Titratable acidity

About 10 g of soup premix was slurried with distilled water, filtered through Whatman No. 1 filter paper, made up to 100 mL, and a 10 mL aliquot was titrated against 0.1 N NaOH using phenolphthalein indicator to a persistent pink end-point. Titratable acidity, expressed as percent citric acid, was calculated as $(T \times N \times V \times E \times 100)/(\text{aliquot volume} \times \text{sample weight} \times 1000)$, where T is the titre value, N the normality of alkali, V the volume made up and E the equivalent weight of citric acid (64) (Ranganna, 1986) [23].

4.5 Bulk density

Bulk density was determined by gently filling a 10 mL graduated cylinder with sample, tapping until no further volume reduction occurred, and calculating bulk density as the ratio of sample weight to volume (Onwuka, 2005) [19].

4.6 Water absorption capacity

A 1 g sample was mixed with 10 mL distilled water for one minute, centrifuged at 5000 rpm for 30 minutes, and the supernatant discarded. Water absorption capacity was calculated from the gain in mass, expressed as grams of water absorbed per gram of sample (Onwuka, 2005) [19].

4.7 Rehydration ratio

A 2 g sample was rehydrated in 20 mL water at constant temperature with agitation at 100 rpm for 10 minutes, blotted to remove surface water, and weighed. Rehydration ratio was calculated as the ratio of rehydrated sample weight to dry sample weight (Krokida & Marinos-Kouris, 2003) [11].

4.8 Particle size distribution

A weighed sample was passed through a stack of sieves of descending aperture size on a mechanical sieve shaker for 15-20 minutes. The material retained on each sieve was weighed and expressed as percent retained (weight retained/total weight × 100); cumulative percent retained and cumulative percent passing were then derived.

5. Microbial quality

Microbiological analysis followed the standard procedures of Harrigan (1998) [6]. Total plate count was determined on Nutrient Agar, coliform count on MacConkey Agar, and yeast and mould count on acidified Potato Dextrose Agar (pH 3.5, adjusted with 10% tartaric acid). Serial dilutions (10^{-2} to 10^{-8}) were plated in triplicate; total plate count plates were incubated at 37 ± 0.5°C for 48 h, coliform plates at 37 ± 0.5°C for 24 h, and yeast and mould plates at 27 ± 0.5°C for 3-5 days. Results were expressed as colony-forming units per gram (CFU/g).

6. Sensory evaluation

Sensory evaluation was carried out using a 9-point hedonic scale, where 1 indicated ‘dislike extremely’ and 9 indicated ‘like extremely’ (Meilgaard *et al*., 1999) [15]. A panel of 11 semi-trained members evaluated colour and appearance, aroma, taste, consistency and overall acceptability in triplicate, and mean scores were used for analysis.

7. Statistical analysis

Data were analysed as a Completely Randomised Design (CRD) with the results of the mixture-design trials, and the

optimum formulation was selected using desirability-function analysis in Design-Expert software, considering all sensory attributes and viscosity as response variables.

Results and Discussion

1. Proximate composition and particle size of raw materials

The proximate composition of mushroom powder, corn starch and soya milk powder is presented in Table 3. Marked differences were observed among the three ingredients, reflecting their distinct functional roles in the formulation: mushroom powder contributed flavour, fibre and nutrients; corn starch functioned mainly as a thickening and bulking agent because of its high carbohydrate content; and soya milk powder improved the protein and overall nutritional quality of the blend.

Soya milk powder recorded the highest crude protein content (49.00 ± 0.90%), followed by mushroom powder (24.74 ± 0.62%), while corn starch contained negligible protein (0.50 ± 0.08%), consistent with its composition as a nearly pure starch fraction. Fat content followed a similar pattern, being highest in soya milk powder (19.50 ± 0.60%) and lowest in corn starch (0.10 ± 0.03%), reflecting the lipid content typical of soybean-derived ingredients. Ash content was highest in mushroom powder (6.47 ± 0.51%), consistent with the known mineral-accumulating capacity of mushrooms, while corn starch showed the lowest ash content because mineral-rich fractions are largely removed during starch purification. Mushroom powder also showed the highest crude fibre content (9.79 ± 0.73%), attributable to chitin and β-glucans in the fungal cell wall, whereas corn starch predominated in carbohydrate content (87.80 ± 1.20%), confirming its intended role as an energy and thickening component.

Table 3: Proximate composition of raw materials (% on dry basis)

Parameter	Mushroom powder	Corn starch	Soya milk powder
Moisture	7.40 ± 0.23	10.90 ± 0.30	4.00 ± 0.20
Crude protein	24.74 ± 0.62	0.50 ± 0.08	49.00 ± 0.90
Crude fat	2.74 ± 0.15	0.10 ± 0.03	19.50 ± 0.60
Ash	6.47 ± 0.51	0.20 ± 0.05	5.00 ± 0.30
Crude fibre	9.79 ± 0.73	0.50 ± 0.10	6.00 ± 0.40
Carbohydrate	48.86 ± 0.80	87.80 ± 1.20	16.50 ± 0.70

Particle size distribution of the three raw materials is shown in Table 4. Mushroom powder showed maximum retention at the 53 µm sieve (30.25 g), soya milk powder at the 63 µm sieve (36.75 g), and corn starch at the 37 µm sieve (25.25 g), indicating that corn starch had the finest particle size of the three ingredients. A fine particle size is generally desirable in instant soup premixes because it improves mixing, dispersion and reconstitution behaviour; the fine particle size of corn starch likely favours rapid swelling and thickening on cooking, while the particle sizes of mushroom powder and soya milk powder support uniform flavour and nutrient distribution in the reconstituted product.

Table 4: Particle size distribution of raw materials (g per 50 g sample)

Sieve size (µm)	Mushroom powder	Soya milk powder	Corn starch
150	0.50	0.75	0.25
106	1.25	1.50	0.50
90	3.00	3.50	1.00
75	6.00	7.50	2.00
63	9.00	36.75	4.00
53	30.25	0.00	6.00
45	0.00	0.00	11.00
37	0.00	0.00	25.25
Total (g)	50.00	50.00	50.00

2. Optimisation of the soup premix formulation

Thirteen formulations, generated by the D-Optimal Mixture Design, were prepared by varying mushroom powder (30-45%) and corn starch (15-30%) while holding soya milk powder and spices constant at 20% each (Table 2, repeated as the basis for Table 5), and were evaluated for colour and appearance, flavour, consistency, after-taste, overall acceptability and viscosity (Table 5).

Significant differences were observed among treatments for all sensory attributes and for viscosity, reflecting the differing contributions of mushroom powder (flavour, colour and mouthfeel) and corn starch (thickness and consistency). Run 6 (45% mushroom powder, 15% corn starch) recorded the highest scores for flavour (8.50 ± 1.26), consistency (8.70 ± 1.24), after-taste (8.70 ± 1.26) and overall acceptability (8.90 ± 1.15), and Run 9, of similar composition, also scored highly, indicating a consistent panel preference for formulations richer in mushroom powder. Viscosity across treatments ranged from 207.40 cP (Run 10) to 246.30 cP (Run 12), with Run 6 also showing high viscosity (244.90 cP); the increase in viscosity with mushroom powder and corn starch level is consistent with greater hydration and swelling of starch and other polysaccharides during cooking.

Table 5: Effect of formulation on sensory attributes and viscosity of mushroom soup premix

Run	Mushroom powder (%)	Corn starch (%)	Colour & appearance	Flavour	Consistency	After-taste	Overall acceptability	Viscosity (cP)
1	30.00	30.00	6.57 ± 1.54	6.24 ± 1.24	6.78 ± 1.30	6.42 ± 1.35	5.78 ± 1.51	210.45
2	37.50	22.50	6.72 ± 1.34	6.47 ± 1.42	7.03 ± 1.36	6.61 ± 0.98	6.25 ± 1.31	221.80
3	35.00	25.00	6.98 ± 1.25	7.29 ± 1.56	7.17 ± 1.30	7.50 ± 0.95	7.23 ± 1.11	223.90
4	30.00	30.00	6.53 ± 1.33	6.14 ± 1.14	6.72 ± 0.92	6.33 ± 1.14	5.83 ± 1.05	216.10
5	40.00	20.00	7.54 ± 1.20	7.22 ± 1.17	7.31 ± 1.01	7.36 ± 1.33	7.24 ± 1.10	227.20
6	45.00	15.00	8.06 ± 1.18	8.50 ± 1.26	8.70 ± 1.24	8.70 ± 1.26	8.90 ± 1.15	244.90
7	33.75	26.25	7.34 ± 1.58	7.99 ± 1.28	7.22 ± 1.28	8.50 ± 1.16	8.00 ± 1.62	225.40
8	37.50	22.50	7.12 ± 1.41	7.54 ± 0.89	7.06 ± 1.18	7.24 ± 1.12	7.21 ± 0.96	216.30
9	45.00	15.00	8.10 ± 1.25	8.41 ± 1.56	8.14 ± 1.20	8.14 ± 1.08	8.12 ± 1.34	239.10
10	30.00	30.00	6.69 ± 1.14	6.22 ± 0.87	6.78 ± 0.16	6.25 ± 1.40	5.72 ± 1.70	207.40
11	37.50	22.50	6.44 ± 1.65	6.50 ± 1.29	6.94 ± 1.22	6.42 ± 1.41	6.11 ± 1.64	223.80
12	41.25	18.75	7.32 ± 1.32	7.14 ± 1.35	7.22 ± 1.42	7.41 ± 1.36	7.21 ± 1.34	246.30
13	45.00	15.00	6.75 ± 1.26	6.61 ± 1.15	7.22 ± 1.33	6.75 ± 1.22	6.69 ± 1.18	237.20

Desirability-function analysis, integrating all sensory attributes and viscosity, identified an optimum formulation containing approximately 44.72% mushroom powder and 15.27% corn starch (with soya milk powder and spices fixed at 20% each), with an overall desirability of 0.721. This formulation combined enhanced mushroom flavour and nutritional quality, contributed by the higher mushroom powder level, with the consistency and body provided by corn starch, and was carried forward for detailed physicochemical, nutritional, microbiological and storage evaluation.

3. Physicochemical and nutritional properties of the optimised soup premix

The nutritional composition of the optimised mushroom soup premix is presented in Table 6. The premix contained 5.92% moisture, a level favourable for shelf stability and reduced microbial spoilage risk, and 5.84% ash, reflecting the mineral contribution of mushroom and soya milk powders. It provided 328.88 kcal/100 g, derived mainly from its carbohydrate (59.99%) and protein (18.45%) content. The relatively high protein level confirms the value of incorporating soya milk and mushroom powders, while the low fat content (1.68%) makes the product suitable for health-conscious consumers. Fibre content (8.12%) reflects the contribution of β-glucans and chitin from the mushroom powder. The premix also supplied calcium (69.40 mg/100 g), iron (1.14 mg/100 g), thiamine (0.18 mg/100 g) and riboflavin (0.24 mg/100 g), micronutrients relevant to energy metabolism and general physiological function.

Table 6: Nutritional composition of the optimised mushroom soup premix (per 100 g)

Parameter	Value
Moisture (%)	5.92 ± 0.21
Ash (%)	5.84 ± 0.18
Energy (kcal)	328.88 ± 2.40
Carbohydrate (%)	59.99 ± 0.85
Protein (%)	18.45 ± 0.52
Fat (%)	1.68 ± 0.12
Fibre (%)	8.12 ± 0.34
Calcium (mg)	69.40 ± 1.15
Iron (mg)	1.14 ± 0.06
Thiamine (mg)	0.18 ± 0.02
Riboflavin (mg)	0.24 ± 0.03

The physicochemical properties of the optimised premix are summarised in Table 7. The pH (6.32 ± 0.04) indicated a near-neutral, slightly acidic product favourable for flavour and stability, while the viscosity (214.75 ± 2.16 cP) reflected the expected thickness on reconstitution, arising from starch gelatinisation and polysaccharide hydration. Bulk density (0.61 ± 0.02 g/mL) was in a range considered favourable for packing, handling and dispersibility of instant food mixes. Water absorption capacity (3.18 ± 0.05 g/g) and rehydration ratio (3.42 ± 0.06) both indicated good reconstitution behaviour, consistent with the hydrophilic protein and fibre content of the formulation. Collectively, these properties indicate that the optimised premix possesses functional characteristics appropriate for instant, convenient preparation.

Table 7: Physicochemical properties of the optimised mushroom soup premix

Parameter	Value
pH	6.32 ± 0.04
Viscosity (cP)	214.75 ± 2.16
Bulk density (g/mL)	0.61 ± 0.02
Water absorption capacity (g/g)	3.18 ± 0.05
Rehydration ratio	3.42 ± 0.06

4. Shelf-life study of the optimised soup premix

The optimised premix was packed in laminated aluminium pouches, chosen for their barrier properties against moisture, oxygen and light, and stored under ambient conditions for 90 days, with quality assessed at 15-day intervals. Table 8 summarises the physicochemical and microbiological changes observed during storage. Moisture content increased gradually from 5.92% to 6.14%, likely reflecting slight moisture ingress despite the barrier packaging, while titratable acidity rose from 0.18% to 0.28%, consistent with slow biochemical and microbial activity over time. Total plate count increased from below detectable levels at day 0 to 2.4 × 10^2 CFU/g by day 90, and yeast and mould, undetectable up to day 15, appeared from day 30 onward and increased gradually thereafter; in all cases, microbial counts remained within generally accepted limits for this product category throughout the 90-day period, indicating that the laminated aluminium packaging was effective in maintaining microbiological safety under ambient storage.

Table 8: Physicochemical and microbiological changes during storage of the optimised soup premix

Storage (days)	Moisture (%)	Titratable acidity (%)	Total plate count (CFU/g)	Yeast & mould (CFU/g)
0	5.92 ± 0.26	0.18 ± 0.12	ND	ND
15	5.95 ± 0.21	0.19 ± 0.08	$(1.2 \pm 0.06) \times 10^2$	ND
30	5.97 ± 0.20	0.22 ± 0.11	$(1.3 \pm 0.09) \times 10^2$	$(1.0 \pm 0.03) \times 10^1$
45	6.02 ± 0.17	0.25 ± 0.21	$(1.7 \pm 0.07) \times 10^2$	$(1.1 \pm 0.05) \times 10^1$
60	6.06 ± 0.15	0.27 ± 0.10	$(1.8 \pm 0.10) \times 10^2$	$(1.7 \pm 0.04) \times 10^1$
75	6.10 ± 0.10	0.26 ± 0.05	$(2.1 \pm 0.08) \times 10^2$	$(1.9 \pm 0.06) \times 10^1$
90	6.14 ± 0.06	0.28 ± 0.02	$(2.4 \pm 0.09) \times 10^2$	$(2.2 \pm 0.05) \times 10^1$

ND = Not detected.

Sensory scores during storage are presented in Table 9. Colour and appearance declined from 8.43 to 8.19 and flavour from 8.36 to 8.10 over 90 days, likely reflecting minor moisture uptake and oxidative flavour changes. Consistency remained comparatively stable throughout storage, indicating that the reconstitution and thickening properties of the premix were largely unaffected. After-taste and overall acceptability also declined gradually but remained within an acceptable range through day 90, confirming that the developed premix retained good sensory quality and consumer acceptability under ambient storage in laminated aluminium packaging.

Table 9: Sensory evaluation of the optimised soup premix during storage

Storage (days)	Colour & appearance	Flavour	Consistency	After-taste	Overall acceptability
0	8.43 ± 0.08	8.36 ± 0.38	8.30 ± 0.22	8.22 ± 0.52	8.34 ± 0.38
15	8.38 ± 0.03	8.31 ± 0.35	8.30 ± 0.19	8.15 ± 0.49	8.27 ± 0.33
30	8.37 ± 0.13	8.28 ± 0.31	8.29 ± 0.14	8.08 ± 0.47	8.21 ± 0.27
45	8.33 ± 0.10	8.23 ± 0.29	8.31 ± 0.15	7.97 ± 0.44	8.16 ± 0.22
60	8.27 ± 0.17	8.15 ± 0.23	8.30 ± 0.13	7.78 ± 0.42	8.08 ± 0.20
75	8.22 ± 0.21	8.11 ± 0.20	8.28 ± 0.09	7.71 ± 0.40	8.05 ± 0.76
90	8.19 ± 0.06	8.10 ± 0.18	8.27 ± 0.06	7.69 ± 0.39	7.98 ± 0.46

Conclusion

The present study successfully developed and optimised an instant mushroom soup premix formulated from oyster mushroom (*Pleurotus sajor-caju*) powder, corn starch and soya milk powder. A D-Optimal Mixture Design combined with desirability-function analysis identified an optimum formulation of approximately 44.72% mushroom powder and 15.27% corn starch (with soya milk powder and spices fixed at 20% each) as giving the best combination of sensory acceptability and viscosity. The optimised premix was nutritionally rich, providing 18.45% protein, 8.12% fibre and only 1.68% fat, and exhibited physicochemical properties — pH, bulk density, water absorption capacity and rehydration ratio favourable for an instant food product. During 90 days of ambient storage in laminated aluminium pouches, the premix remained microbiologically safe and sensorially acceptable, with only gradual changes in moisture, acidity and microbial counts. These findings demonstrate that oyster mushroom can be successfully value-added into a nutritionally enriched, shelf-stable instant soup premix, offering a promising avenue to increase the utilisation and market potential of oyster mushroom while supporting grower incomes and providing consumers with a convenient, nutritious food option. Future work could examine consumer-scale sensory validation, cost-benefit analysis of commercial-scale production, and extended storage trials under varied packaging and climatic conditions.

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