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Development, Nutritional and Sensory Evaluation of Chickpea – Based Instant Hummus Powder Enriched with Indian Spices and Beetroot

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Abstract

Chickpea (*Garbanzo beans*) is a globally important legume celebrated for its high plant-based protein (17–29%), complex carbohydrates, dietary fibre, and rich collection of bioactive phytochemicals. While traditional hummus prepared from chickpea is nutritionally excellent, its high moisture content (60–70%) limits shelf life to 7–10 days under refrigeration, severely limiting distribution and expandability. Two chickpea-based instant hummus powder formulations — Sample B (Indian Spiced Instant Hummus Powder) and Sample C (Beetroot Enriched Instant Hummus Powder) were developed and evaluated, next to a freshly prepared standard hummus control (Sample A). This was done to define the proximate nutritonal composition and sensory acceptability. Raw chickpeas were processed through sequential cleaning, soaking (10–12 hours), boiling to tenderness, hot-air oven drying, and fine grinding; beetroot was independently washed, peeled, sliced, dried, and powdered. Sample B was formulated at 60 g chickpea powder, 10 g sesame (tahini) powder, 2 g each of garlic powder, lemon peel powder, salt, cumin powder, and coriander powder, with 1 g red chilli powder, 0.5 g turmeric, and 1.5 g garam masala per 100 g. Sample C incorporated 55 g chickpea powder, 10 g beetroot powder, 8 g sesame powder, 5 g garlic powder, and reduced spices. Proximate composition was determined by AOAC (2000) official methods: moisture by gravimetric oven-drying at 105 ± 2°C, ash by muffle furnace incineration at 550°C, protein by Kjeldahl method (N × 6.25), crude fat by Soxhlet extraction with diethyl ether, and carbohydrate by difference. Sensory evaluation was conducted by a semi-trained panel of 16 judges using a standard 9-point hedonic scale for five attributes (appearance, taste, aroma, mouthfeel, overall acceptability), with one-way ANOVA applied to detect inter-formulation differences ($\alpha = 0.05$).

Results obtained from proximate analysis showed that Sample B had a moisture content of 5.33%, protein content of 28.46%, fat content of 20.18%, ash content of 5.49%, and carbohydrate content of 40.54%. Sample C was characterized by a moisture content of 5.98%, protein content of 23.14%, fat content of 15.34%, ash content of 4.54%, and carbohydrate content of 51.00%. Sensory assessment results showed that Sample B had an average acceptability score of 8.23 ± 0.54 and higher scores regarding taste (8.44 ± 0.63), mouthfeel (8.44 ± 0.51), and total acceptability (8.25 ± 0.45). In turn, Sample C performed better in
appearance (8.50 ± 0.52) owing to red-purple pigmentation caused by betanin. Statistical significance was proved in regard to differences in formulations in appearance ($F = 4.355$, $p = 0.031$), taste ($F = 6.697$, $p = 0.009$), mouthfeel ($F = 15.474$, $p = 0.002$), and acceptability ($F = 6.000$, $p = 0.019$); no differences were detected concerning aroma ($F = 0.077$, $p = 0.754$). Sample B and Sample C products appeared to have acceptable total score above 7.5 ('Like Very Much'), indicating their commercial viability. Both the formulations are commercially viable, nutritionally superior alternatives to fresh hummus, with Sample B exceeding on taste and mouthfeel and Sample C excelling in colour, derived through natural betanin making them suitable for ambient distribution across India and Global markets.

Keywords: Instant hummus powder; Proximate composition; Hedonic scale; betalain; Indian spices; functional food; AOAC Methods; Protein Enrichment.

1.Introduction

Garbanzo beans, or more formally, chickpeas, rank as the third most popular crop among food legumes next to soybean and groundnut with an annual yield of 15+ millions of metric tonnes produced annually on an area of more than 14 million across more than 50 countries worldwide. India is the leader in chickpea production providing between 65% and 70% of global production mostly in Madhya Pradesh, Rajasthan, Uttar Pradesh, and Maharashtra states. Nutritional value of chickpeas includes 17% to 29% of crude protein, 15-22% of dietary fiber, 4-7% of fat, and rich in several vitamins (folic acid, niacin, thiamine) and minerals (iron, zinc, calcium, phosphorus, magnesium). Thus, chickpeas are the main source of proteins in South Asian countries and sub-Saharan Africa[20,28]. Protein digestibility corrected amino acid score (PDCAAS) in processed chickpeas ranges from 0.71 to 0.78, and its relatively high content of lysine (7.2-7.8 g/16gN) makes chickpea perfect protein rich cereal diets that are poor in this amino acid[14].

Hummus or 'hummus bi tahini' as per Arabic language means the food prepared by mixing cooked chickpeas with sesame paste, lemon juice, garlic, olive oil, and salt. The nutritional value of hummus includes the presence of protein in the range of 5-7 g, dietary fiber in the range of 4-6 g, unsaturated fatty acids, and vitamins B6, C, folate in addition to iron, zinc, and phosphorus in 100g of fresh hummus. There exist relationship between the regular use of hummus and the higher diet quality score, BMI score, dietary fiber intake, folate intake, and vitamins A, C, and E intake in comparison to hummus non-users[23].

Traditional fresh hummus has, however, limited commercial appeal because of its high perishability due to high moisture content (60–70%) that enables fast microbial proliferation including pathogenic bacteria such as Listeria monocytogenes and Salmonella spp., along with spoilage fungi. This reduces its shelf-life up to 7–10 days at 4°C refrigerated storage conditions and mandates cold-chain transportation limiting sales to local marketplaces, imposing high energy and logistical cost on producers. Transformation of fresh hummus into a powdered instant form solves this issue through lowering of moisture content to less than 8%, along with water activity (Aw) below 0.35, inhibiting microbial, enzymatic, and oxidative degradation reactions, resulting in up to 12–24 months ambient storage capability without use of chemical preservatives or refrigeration. Instantisation can be accomplished by adding water or oil to the dried hummus powder, giving it back its creamy texture and taste. The functional properties of chickpea, including high water absorption capacity (WAC), oil absorption capacity (OAC), emulsion stability, and gelling property, make it a potential candidate for instant food powder formulation[2,15].

Value addition through functional ingredient incorporation represents a key strategy for product differentiation and premium market positioning. Beetroot (Beta vulgaris L.) is among the richest dietary sources of betalain pigments, which constitutes 75–95% of total betalain content and imparts the characteristic deep red-purple colour — alongside exceptional inorganic nitrate content (250–500 mg NO_3^-/100 g fresh weight) and a potent antioxidant capacity exceeding that of vitamin C on a molar basis. Betanin exhibits documented anti inflammatory properties, and beetroot's nitrate content supports endogenous nitric oxide synthesis, causing vasodilation and reducing systolic blood pressure by 4–10 mmHg in clinical trials[9,18,31]. Indian spices such as coriander (linalool, flavonoids), cumin (cuminaldehyde, terpenoids), turmeric (curcumin, ar-turmerone), red chilli (capsaicin, capsanthin), and garlic (allicin, diallyl sulphides) collectively contribute antioxidant and flavour-enhancing properties that elevate both the functional value and the sensory appeal of the finished product[4,21,29].

Despite the growing market for legume-based convenience foods and the well-documented health properties of both chickpea and beetroot, peer-reviewed literature specifically addressing the development and physicochemical characterization of chickpea-based instant hummus powder enriched with beetroot and Indian spices remains limited. This study therefore aimed to: (i) develop and standardize two chickpea-based instant hummus powder formulations incorporating Indian spices and beetroot respectively; (ii) determine their proximate nutritional composition using AOAC (2000) standard methods; and (iii) evaluate their sensory acceptability using a 9-point hedonic scale and one-way ANOVA. The findings provide a rigorous scientific basis for the scale-up, commercial development, and nutritional labelling of these novel functional food products.

2. Materials and Methods

2.1 Collection of Raw Materials

Chickpea flour (Kabuli variety), Sesame seeds, Beetroots (fresh) along with all the spices powders such as roasted cumin powder, coriander powder, turmeric powder, red chilli powder, garlic powder, garam masala and chaat masala was purchased from local stores certified from the city of Lucknow, Uttar Pradesh, India. Apart from this, other materials used in this experiment include Lemon peel powder (as an alternative of fresh lemon juice for calibrating acid content in a food material), Salt and Beetroot Powder for Sample C. All materials were inspected visually prior to their use to ensure there was no foreign contamination.

2.2 Development and Standardization of Hummus Powder Formulations The control fresh hummus formulation (sample A) was prepared by soaking the washed and clean chickpeas in tap water for 10-12 hours, boiling until fully tender, mixing the mixture with other ingredients like tahini, garlic, fresh lemon juice, olive oil and salt leading to the formation of homogeneous mixture. Taste and texture provided the basis for developing powder formulation. In the Sample B and Sample C, the olive oil is used in the powder form.

Powder formulations development involved washing and cleaning chickpeas, soaking for 10- 12 hours, boiling until fully tender, cooling, placing the chickpeas uniformly on stainless steel trays and drying the product in hot air oven until fully dehydrated. The dry chickpeas were then reduced to chickpea flour by grinding using a commercial pulverizer. For the beetroot powder, the beetroot was washed, peeled, cut into pieces of about 3-4mm, dried in hot air oven at 55°C so as not to reduce much of betanin content, then grounded to form beetroot powder. The sesame seeds were toasted and ground into sesame powder (tahini). All ingredients were mixed in specific proportions as shown in Table 1 and processed to get homogenous mixture by food processor. The mixture was finally sieved through 40-mesh sieve and packed in airtight glass containers.

Table 1. Ingredients List of Indian Spiced Instant Hummus Powder (Sample B) and Beetroot Enriched Instant Hummus Powder (Sample C)

Ingredient	**Sample B – Indian Spiced (g per 100g batch)**	**Sample C – Beetroot Enriched(g per 100g batch)**
Chickpea Flour	60.0	55.0
Beetroot Flour	-	10.0
Sesame (Tahini) Powder	10.0	8.0
Garlic Powder	2.0	5.0
Lemon Peel Powder	2.0	2.0
Salt	2.0	2.0
Roasted Cumin Powder	2.0	2.0
Coriander Powder	2.0	2.0
Red Chilli Powder	1.0	1.0
Turmeric Powder	0.5	0.5
Garam Masala	1.5	1.5
Chaat Masala	2.0	1.0

Total	88.0*	90.0*

**Remaining balance to 100g compromised oil powder not listed separately; formulations do not include free oil for powder stability.*

2.3 Proximate Analysis

Proximate composition of both instant hummus powder formulations was determined following the official methods of the Association of Official Analytical Chemists[1]. All analyses were performed in triplicate and results are expressed as mean percentage on a wet weight (as-is) basis.

Moisture content was determined gravimetrically. A pre-dried, tared petri dish was weighed (W_1), 5 g of sample was added and weighed (W_2), and the dish with sample was dried in a hot air oven at 105 ± 2°C until constant weight was achieved (W_3), with intermediate cooling in a desiccator for 10–15 minutes before each weighing. Moisture (%) = $(W_2 – W_3) / (W_2 – W_1) \times 100$ (AOAC Method 925.10).

Ash content was determined by complete incineration. A pre-ignited, tared porcelain crucible was weighed (W_1), 5 g of sample was placed and weighed (W_2), and the crucible was transferred to a muffle furnace and heated at 550°C for 4 hours until a white or grey ash was obtained. After cooling in a desiccator, the crucible was weighed (W_3). Ash (%) = $(W_3 – W_1) / (W_2 – W_1) \times 100$ (AOAC Method 923.03).

Crude protein was determined by the macro-Kjeldahl method (IS: 7219-1973; AOAC Method 984.13). A 0.2 g sample was digested with 20 mL concentrated sulphuric acid in the presence of a catalyst mixture (potassium sulphate and cupric sulphate) in a Kjeldahl digestion flask until the solution became clear. The digest was transferred to a distillation unit, alkalized with 40% NaOH (50 mL), and steam-distilled into 30 mL of 4% boric acid receiver solution. The distillate was titrated against 0.1 N HCl with methyl red indicator. Protein (g/100 g) = (Volume of HCl consumed × Normality × 14 × 6.25 × 100) / (Sample weight × 1000). A nitrogen-to-protein conversion factor of 6.25 was applied (Kjeldahl, 1883)[19].

Crude fat was determined by Soxhlet extraction (AOAC Method 920.39). A moisture-free 2 g sample was packed in a filter paper thimble and placed in the siphon of a Soxhlet apparatus. Anhydrous diethyl ether (250 mL) was used as the extracting solvent. Extraction was carried out for 17–18 cycles (approximately 6 hours) at 34°C. The ether was evaporated from the collection flask on a water bath at 34–68°C, and the fat residue was dried in a desiccator for 15 minutes and weighed. Fat (%) = $(W_4 – W_3) / (W_2 – W_1) \times 100$, where W_1 = empty thimble, W_2 = thimble + sample, W_3 = empty flask, W_4 = flask + fat.

Carbohydrate content was calculated by difference: Carbohydrate (%) = 100 − (Moisture% + Protein% + Fat% + Ash%) (SP 18 P-6, 1981). Total metabolizable energy was estimated as: Energy (kcal/100 g) = 4 × (Protein + Carbohydrate) + 9 × Fat, using Atwater general factors.

2.4 Sensory Evaluation

Sensory evaluation of the two instant hummus powder formulations (Samples B and C) was conducted on 25th March 2026 by a semi-trained panel of 16 members (n = 16; mixed gender, aged 20–35 years) recruited from the student and faculty community of the Department of Food and Nutrition, BBAU Lucknow. Panellists were oriented on the use of the 9-point hedonic scale (1 = Dislike extremely; 5 = Neither like nor dislike; 9 = Like extremely) and the sensory attributes to be evaluated (appearance, taste, smell/aroma, mouthfeel, and overall acceptability). Each formulation was reconstituted with distilled water at a standardized powder-to-water ratio (1:2 w/v), stirred to homogeneity, and served in coded opaque containers at room temperature (25 ± 2°C). Samples were presented in randomized order to eliminate order and carry-over bias. Panellists rinsed their palates with plain water between samples. The freshly prepared standard hummus control (Sample A) was evaluated separately on a prior date with a panel of sixteen members (n = 16) using the same scale. Statistical analysis of inter-formulation differences was performed using one-way Analysis of Variance (ANOVA), with the level of significance set at $\alpha = 0.05$. The F-critical value at $df_1 = 1$, $df_2 = 30$ and $\alpha = 0.05$ was 4.171. Post-hoc interpretation was based on p-values relative to the $\alpha = 0.05$ and $\alpha = 0.01$ thresholds. Sensory evaluation methodology followed[27].

3. Results and Discussion

3.1 Proximate Composition

Table 2 gives the proximate composition of both instant hummus powder formulations. The presence of macronutrients in both powder samples confirmed that their nutritional properties were in agreement with those of premium quality leguminous functional food powders but with certain distinctions which arose due to the variation in ingredient contents, namely beetroot powder and Indian spices.

Table 2: Proximate Composition (% on wet weight basis) of Indian Spiced Instant Hummus Powder (Sample B) and Beetroot Enriched Instant Hummus Powder (Sample C)

Parameter	Sample B (Indian Spiced, %)	Sample C (Beetroot Enriched, %)	Reference Range (Chickpea – based powders)
Moisture Content	5.33	5.98	< 8.0% (FSSAI/AOAC)
Ash Content	5.49	4.54	2.5 – 5.5%
Crude Fat Content	20.18	15.34	4–7% (raw chickpea)
Crude Protein Content	28.46	23.14	17–29% (raw chickpea DWB)
Carbohydrate Content	40.54	51.00	55-65% (raw chickpea DWB)
Estimated Energy (kcal 100g)	463.5	425.2	-

DWB = Dry Weight Basis. Estimated energy calculated using Atwater factors: 4 kcal/g protein and carbohydrate; 9 kcal/g fat.

Moisture content was 5.33% in Sample B and 5.98% in Sample C, both well within the ≤8% threshold established for microbiologically safe dehydrated food products[1,22]. Moisture content below 8% ensures water activity (Aw) below 0.35 in well-formulated powder systems, a level at which growth of bacteria, yeasts, and moulds is completely inhibited, conferring ambient-temperature shelf stability. The marginally higher moisture in Sample C is attributable to the hygroscopic nature of beetroot powder, which contains substantial sucrose (6–10 g/100 g fresh weight). These values are consistent with moisture contents of 4.8–6.5% reported for chickpea flour and legume-based instant powder products in the literature[15].

The value of ash content (total inorganic mineral content left behind after combustion) in Sample B was significantly higher than that in Sample C, registering values of 5.49% and 4.54%, respectively. This difference can be attributed to the use of mineral-rich Indian spices in Sample B as the ingredient content and quantity is higher than that in Sample C. For example, coriander contains calcium (709 mg/100 g), iron (16.3 mg/100 g), and manganese, while cumin has iron (66.4 mg/100 g), calcium (931 mg/100 g), and magnesium (931 mg/100 g). Garlic has potassium (1193 mg/100 g) and phosphorus (153 mg/100 g). Similarly, chickpea contains iron (3.6-5.2 mg/100 g DW), zinc (2.8-3.4 mg/100 g), calcium (100-150 mg/100 g), and phosphorus (290-350 mg/100 g). Thus, chickpea makes up for a significant share of minerals in these formulations and both the values of ash content are within normal mineral content range of the functional food products[16,28].

Fat content was highest in Sample B (20.18%), whereas, Sample C contained 15.34% fat. This large discrepancy between the fat contents of Sample B and Sample C could be attributed to a higher portion of tahini (10 g vs 8 g per 100 g). In addition to this, sesame powder is lipid-rich (~50-55% fat) and consists of oleic acid (18:1, ~38%) and linoleic acid (18:2, ~42%). Besides, sesame lipids have an added advantage of being rich in lignans like sesamin, sesamolin, and sesamol which act as powerful antioxidants inhibiting lipid oxidation[33]. Chickpea, too, has about 4-7% fat with a P/S ratio >2.0 containing oleic acid (18-32%) and linoleic acid (48-64%) as the primary fatty acids[32]. Sample C has a low-fat content due to partial replacement of sesame powder by beetroot powder (~0.2 g fat/100 g fresh matter). As in the case of ash content, fat content is high in both samples, reflecting their functional nature, compared to conventional hummus (6-10 g/100 g).

The concentrations of crude protein for Samples B and C were 28.46% and 23.14%, respectively, corresponding to about 2.8–4.0 times higher than those in standard fresh hummus protein content, which averages at about 5-7 g/100 g. Both levels are considered excellent in plant-based protein content based on international standards and far exceed the protein content in commercial legume-based instant foods (usually 15-22%). The increased amount of protein in Sample B is due to an increased chickpea powder content (60 g vs. 55 g), higher protein content in sesame powder (tahini protein content: 22-25%), and the sum effect of increased Indian spice protein powders. On the other hand, a lower protein content in Sample C is attributed to the partial replacement with beetroot powder, the protein content of which is only around 1.6 g/100 g fresh weight or 10-12 g/100 g dry weight. Chickpea protein is rich in legumin (11S globulin), vicilin (7S globulin), albumins, and small amounts of glutelins. It has a PDCAAS score ranging from 0.71-0.78 and is distinguished by its balanced composition of essential amino acids with high lysine content (7.2-7.8 g/16 g N), balancing cereal deficient essential amino acid profile[14,34].

Carbohydrates in Samples B and C were determined by difference, yielding values of 40.54% and 51.00%, respectively. This relatively high carbohydrate content in Sample C is due to high sucrose content (6-10 g/100 g of fresh weight) in beetroots multiplied by concentration factor of 8-10 after drying to power form and high dietary fiber content (2.8 g/100 g of fresh weight) in beetroots. Addition of chickpea will make proportion of amylose in starch relatively high (35-45% versus 20-25% in cereal starch). As a result, low GI products (GI = 28-36 in cooked chickpeas) with relatively high amount of resistant starch (RS) will be synthesized. RS functions as prebiotic for intestinal bifidobacteria and lactobacillus populations decreasing postprandial glucose level[10,20]. Dietary fibers in chickpea (15-22% DW) include both soluble dietary fiber components (pectin, β-glucan, and hemicellulose, 5- 8% DW) forming viscous gel delaying gastric emptying, decreasing glucose absorption, and insoluble fractions (cellulose and lignin, 8-14% DW) increasing stool volume. Metabolizable energy content of Sample B and Sample C is estimated to be 463.5 kcal/100 g and 425.2 kcal/100 g, respectively.

3.2 Sensory Evaluation – Control (Sample A)

The freshly prepared standard hummus (Sample A, control) was evaluated by a panel of 16 members. Mean hedonic scores were: appearance 7.69/9, taste 7.69/9, mouthfeel 7.56/9, and aroma 7.25/9, with an overall acceptability score of 7.69/9. All attributes fell in the 'Like Moderately' to 'Like Very Much' range (7.0–8.0), confirming that the developed standard hummus formulation based on soaked, boiled, and blended chickpea with tahini, garlic, lemon juice, olive oil, and salt serves as a well-accepted sensory baseline consistent with texture and flavour profiles reported for commercial hummus by[26].

3.3 Sensory Evaluation – Instant Hummus Powder Formulations (Sample B and Sample C)

Mean hedonic scores (± SD) for all five sensory attributes and both instant hummus powder formulations are presented in Table 3. The grand mean scores were 8.23 ± 0.54 for Sample B and 7.87 ± 0.69 for Sample C. All individual attribute means for both formulations exceeded the hedonic midpoint of 5.0 ('Neither like nor dislike'), falling in the 'Like Very Much' to 'Like Extremely' region of the scale (7.56–8.50). This confirms that both formulations are palatable and acceptable across all sensory dimensions, with scores comparing favourably to acceptability thresholds (≥7.0) used in applied food product development[27].

Table 3. Mean Hedonic Ratings (± SD) of Sample B (Indian Spiced) and Sample C (Beetroot Enriched) Instant Hummus Powder using a 9 Point Hedonic Scale (n = 16 Panellists)

Sensory Attributes	Sample B Mean ± SD	Sample C Mean ± SD	Difference (B-C)
Appearance	8.12 ± 0.50	8.50 ± 0.52	-0.38 (C preferred)
Taste	8.44 ± 0.63	7.75 ± 0.86	+0.69 (B preferred)*
Smell (Aroma)	7.88 ± 0.62	7.81 ± 0.66	+0.07 (NS)
Mouthfeel	8.44 ± 0.51	7.56 ± 0.73	+0.88(B preferred)**
Overall Acceptability	8.25 ± 0.45	7.75 ± 0.68	+0.50 (B preferred)
Grand Mean	8.23 ± 0.54	7.87 ± 0.69	+0.36

*NS = Not Significant; *p<0.05; **p<0.01 (One – Way ANOVA; F – critical at* $df_{1=1}$, $df_2 = 30$, $\alpha = 0.05 = 4.171$*)*

3.4 One – Way ANOVA Results for Sensory Attributes

The analysis of variance outcomes for all sensory characteristics are shown in Table 4 below. Here, F value is determined as the division of between-group means squares by within-group means squares, where $df_1 = 1$ (between group) and $df_2 = 30$ (within group, based on 16 participants from each sample group minus 1, (16 – 1) + (16 – 1) = 30.

Table 4. One-way ANOVA Analysis Summary for Sensory Characteristics of Sample B and Sample C ($df_1 = 1$, $df_2 = 30$; F-critical = 4.171 at $\alpha = 0.05$)

E	SS Between	SS Within	MS Between	MS Within	F - Value	p - Value	Result
Appearance	1.125	4.000	1.125	0.133	4.355	0.031	* Sig.
Taste	3.803	17.060	3.803	0.569	6.697	0.009	** Sig.
Aroma	0.031	6.500	0.031	0.217	0.077	0.754	NS
Mouthfeel	6.125	11.880	6.125	0.396	15.474	0.002	** Sig.
Overall Acceptability	2.000	10.000	2.000	0.333	6.000	0.019	* Sig.

*NS = Not Significant; *p< 0.05; **p < 0.01; SS = Sum of Square; MS = Mean Square*

Appearance (F = 4.355, p = 0.031): Sample C was significantly preferred for appearance (8.50 ± 0.52 vs 8.12 ± 0.50). The visually striking deep red-purple colour of Sample C is solely attributable to betanin. Betanin absorption maximum at 535–540 nm in the visible spectrum produces the characteristic magenta-red colouration visually recognised by panellists as highly attractive.It similarly reported that beetroot powder incorporation at 1–5% in confectionery products significantly enhanced CIE a* values (red-green axis) and consumer colour preference scores proportional to betanin concentration, consistent with the present finding[12].

Taste ($F = 6.697$, $p = 0.009$): The superiority of Sample B was evident by its better taste (8.44 ± 0.63 vs 7.75 ± 0.86). The taste profile of Sample B is associated with the harmonious synergy among various spices used in Sample B: citrus flavor with the linalool content of coriander seeds, distinct earthiness from cumin containing cuminaldehyde, bitter and warm flavor from turmeric, graded capsaicin-based pungency from red chilli, and allicin-containing pungency from the garlic. It reported the ability of addition of coriander and cumin powders to increase sensory flavor ratings of the products, as a result of the increased concentration of volatile compounds[4].It was observed that the synergistic action of essential oil extracts of both spices as regards antimicrobial and antioxidant activity, therefore, the flavor of the spices should act synergistically as well[5]. The low rating of Sample C could be explained by the characteristic earthy-sweet aroma of the beetroot.

Aroma ($F = 0.077$, $p = 0.754$): There were no differences between Samples B and C in terms of their aromas (7.88 ± 0.62 vs 7.81 ± 0.66). It is attributed to the identical formulations used for making each of the two samples. Namely, it consists of the mixture of chickpeas, tahini, cumin, and coriander which produce similar aroma in each mixture. As such, the samples had the same aroma since they contained the identical volatile compounds of garlic-cumin-coriander, providing a typical South Asia-based spiced aroma for both of them despite different amounts of beetroot added.

Mouthfeel ($F = 15.474$, $p = 0.002$): The most significant difference ($p = 0.002$) is associated with the mouthfeel aspect of the sample quality with significantly higher scores obtained for Sample B (8.44 ± 0.51 vs 7.56 ± 0.73). The more favorable mouthfeel of the Sample B is caused by its higher protein content (28.46%) and fat content (20.18%). The protein-lipid matrix obtained after reconstitution is richer because of the larger quantities of proteins and lipids in the sample. Chickpea globulin proteins contribute to the development of emulsions, gels, and other types of mouthfeel owing to their specific secondary structures such as 11S legumins rich in β-sheets and 7S vicilins with α-helices[34]. Sesamine and sesamol in tahini contribute to the development of oil-in-water emulsions, making Sample B mouthfeel very pleasant and unctuous[33]. Poorer mouthfeel quality in Sample C arises because it contains less protein- and lipid-rich ingredients (chickpea and sesame) than Sample B and contains a relatively low-protein ingredient (beetroot powder).

3.5 Functional Bioactive Parameters

Beyond proximate composition, functional bioactive parameters were characterized to establish the nutraceutical value profile of the formulations. Total Phenolic Content (TPC), measured by the Folin-Ciocalteu colorimetric method[30], was 5.19 mg gallic acid equivalents (GAE)/g in Sample B and 1.87 mg GAE/g in Sample C. The substantially higher TPC of Sample B reflects the concentrated polyphenol contribution of its Indian spice blend: curcumin and curcuminoids from turmeric (2–5% DW), phenolic acids (caffeic, ferulic, p coumaric, chlorogenic) from coriander, phenolic aldehydes from cumin, and organosulphur phenolics from garlic, all of which register high absorbance in the Folin-Ciocalteu assay[21].
Total Flavonoid Content (TFC), measured by the aluminium chloride colorimetric method[8], was nearly identical: 9.09 mg quercetin equivalents (QE)/g in Sample B and 9.17 mg QE/g in Sample C. This equivalence confirms that chickpea's isoflavone and flavonol fraction (biochanin A, formononetin, quercetin, kaempferol) which is the primary flavonoid source in both formulations is preserved consistently regardless of whether beetroot or additional Indian spices constitute the functional additive[17,24]. Antioxidant activity measured by DPPH radical scavenging assay[7] was recorded for Beetroot Hummus Powder (Sample C) at 364.26 mg/g ascorbic acid equivalents (AAE), reflecting the powerful radical scavenging capacity of betanin (ORAC) value ~500 µmol Trolox equivalents/g) and the phenolic compounds of beetroot and chickpea[18]. The pH of both formulations was mildly acidic: 3.948 for Sample B and 3.814 for Sample C, consistent with inclusion of lemon peel powder and citric acid, and within the pH range (4.0–5.0) at which betanin exhibits maximum stability[31]. Total Soluble Solids were 1.6° Brix for Sample B and 2.6° Brix for Sample C, with the higher TSS in Sample C reflecting the greater dissolved sugar contribution of beetroot sucrose.

4. Conclusion

Two chickpea – based instant hummus powder formulations Sample B (Indian Spiced) and Sample C (Beetroot Enriched) are successfully developed, characterized and evaluated. Both formulations accomplished low moisture content indicating that they are free from microbial spoilage and are suitable for surrounding temperature without the refrigeration and chemical preservatives.

From a nutritional point of view, Sample B delivered exceptional crude protein content and fat content , positioning it as a high-protein, energy-dense functional food well-suited to protein-supplementation and athletic nutrition contexts. Sample C, with its higher carbohydrate content, lower fat , and elevated dietary fibre from beetroot, offers a metabolically favourable nutritional profile appropriate for fibre-conscious, low-GI, and weight-management dietary patterns. Both formulations substantially exceed the macronutrient density of conventional fresh hummus due to the concentration effect of dehydration.

Sensory evaluation clearly supported consumer acceptability: Sample B achieved statistically superior scores for taste, mouthfeel, and overall acceptability, driven by its well-balanced Indian spice flavour profile and protein-lipid-mediated creamy reconstituted texture. Sample C achieved significantly superior appearance scores reflecting its betanin-derived red-purple visual distinctiveness. Both formulations scored above the commercial viability threshold for overall acceptability.

Based on the combined results, Sample B (Spiced Instant Hummus Powder) is better suited for markets where taste and protein content are primary drivers such as fitness and sports nutrition segments. On the other hand, Sample C's (Instant Hummus Powder containing Beetroot) natural red – purple colour gives it an advantage in clean – label and visually –
driven retail contexts where synthetic dyes are being phased out.

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Conflict of Interest

Statement of conflict of interest: The authors have no conflicts of interest, either financial or otherwise, to declare concerning the present study. Present research is carried out as part of partial fulfillment of Master of Science in Food & Nutrition from Babasaheb Bhimrao Ambedkar University, Lucknow. No funding or support was obtained for carrying out the research or writing the paper.

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