



ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating: 4.97
IJAFA 2025; 7(6): 80-88
www.agriculturaljournals.com
Received: 18-03-2025
Accepted: 22-04-2025

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Development of a nutri-rich roasted legume-based snack

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DOI: <https://www.doi.org/10.33545/2664844X.2025.v7.i6b.442>

Abstract

The current research focuses on formulating a nutrient-rich, ready-to-eat (RTE) snack from six locally grown legumes; peanut, green gram, cowpea, field bean, horse gram and soybean using various unit operations involving soaking, germination, and roasting. Two formulations were standardized with varying combinations of legumes and tested for physical, chemical, and sensory properties. Treatments involving soaking of legumes in 0.2% salt, 0.5% alum, and both salt and alum together were evaluated as per the sensory scores. Physical analysis indicated seed weight and dimensions were higher after soaking and germination due to water absorption, and bulk and true density were lower after roasting. Chemical analysis indicated that nutrient profiles were consistent for all treatments, except for slightly lower moisture (4.48%), but increased protein (22.22 %), fat (2.37%), and similar fiber content (8.01%) in formulation 2 compared to formulation 1. Sensory acceptance was verified to be higher for formulation 2, and accelerated shelf-life testing over 30 days proved good product stability. Such results verify the viability of a healthy, legume-based snack product with longer shelf life and better nutritional value.

Keywords: Legume, snacks, salt-alum soaking, germination, roasting

1. Introduction

With increasing needs for easy, healthy, and stable food, innovation has accelerated in the ready-to-eat (RTE) snack market. With rising awareness of the relationship between food habits and long-term health outcomes, consumers are moving toward functional food products that provide both short-term satisfaction and long-term nutritional value. Yet most RTE snack foods sold in the market are still dominated by refined carbs, saturated fats, high sodium content, and artificial preservatives presenting potential risks like obesity, heart disease, and metabolic illness (Rasane *et al.*, 2015) ^[20].

Interest in using plant based food ingredients is on the increase to fill this nutritional inadequacy gap. Among these, legumes are particularly promising because of their nutrient-dense profile and sustainability. Legumes are a good source of high-quality plant proteins, dietary fiber, complex carbohydrates, and essential micronutrients like iron, magnesium, zinc, and B-vitamins (Duranti, 2006; Mudryj, *et al.*, 2014) ^[5, 17]. They also possess health-benefiting bioactive compounds like polyphenols, phytosterols, and oligosaccharides, which are responsible for antioxidant, cholesterol-lowering, and anti-inflammatory activities (Rochfort and Panozzo, 2007) ^[22].

Although their nutritional advantages are well documented, legumes are still underexploited in the commercial snack market, especially in developing nations, where manufactured snacks tend to be high in energy but low in nutrients. This study seeks to fill that gap by formulating a legume based snack not just to satisfy nutritional requirements but also to conform to the rationale of sustainable and cheap food production.

This study centers on six legumes: Peanut (*Arachis hypogaea*), Green gram (*Vigna radiata*), Cowpea (*Vigna unguiculata*), Field bean (*Lablab purpureus*), Horse gram (*Macrotyloma uniflorum*), and Soybean (*Glycine max*). Each of these legumes offers unique nutritional values. For instance, green gram provides very digestible protein and antioxidants, soybeans are an isoflavone-containing complete protein source, and peanuts, while containing more fat, provide energy density and essential fatty acids.

(Messina, 1999; Tang *et al.*, 2014; Sreerama *et al.*, 2012) [14, 27, 26]. Horse gram and field bean legumes, although less consumed in conventional products, are mineral and fiber rich and have the potential to be included in value-added food formulations.

2. Materials and Methods

Six Legumes-Peanut (*Arachis hypogaea*), Green gram (*Vigna radiata*), Cowpea (*Vigna unguiculata*), Field bean (*Lablab purpureus*), Horse gram (*Macrotyloma uniflorum*), and Soybean (*Glycine max*) were procured from the local market of Pune. The procured legumes were cleaned, sorted, and packed in polythene bags for further process.

2.1 Standardization of product making process

The product was being prepared in 3 states: soaking, germination, roasting (Figure 1). Preliminary trials were undertaken to standardize the process for making/production of the product.

- **Soaking:** The soaking was carried out with various concentrations of solvents (0.2, 0.5 and 0.7%) each of salt and alum. The final concentrations were finalized based on sensory analysis.
- **Germination:** The germination was carried out for 48 hours at room temperature (27±1°C)
- **Roasting:** Salt roasting was performed at a temperature range of 150-200°C to ensure uniform roasting.

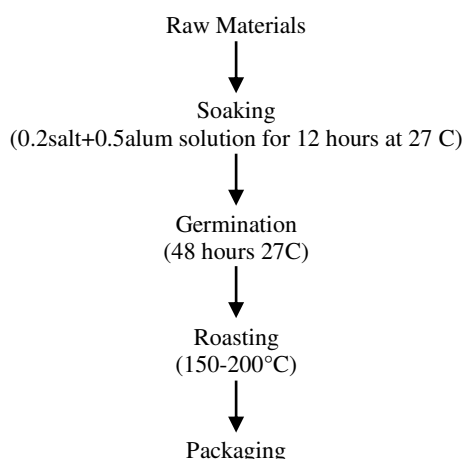


Fig 1: Process flow chart for preparation of legume snacks

2.2 Product Standardization

The product was formulated in two combinations. The formulation-1 contained equal proportions of all six legume seeds (1:1:1:1:1:1), whereas formulation-2 contained higher levels of Peanut, Field bean, Horse gram, and Soybean with lower proportion of Cowpea and Green gram (2:2:2:2:1:1). The formulation was standardized based on the physicochemical and sensory properties.

2.3 Physical Analysis

To assess the physical properties of legume seeds, routine procedures were used to measure seed weight, size measurements, geometric mean diameter, sphericity, bulk density, true density, and porosity. The experiments were performed at room temperature (27±1°C) and each measurement was made in triplicate for precision.

- **100-Seed Weight (g):** A total of 100 seeds were manually counted and weighed on a digital analytical balance (Model: Contech CTL Series). 100 seed weight

is an important measure of overall yield (Deshpande *et al.*, 1982) [4].

- **Seed Dimensions (Length, Width and Thickness):** Ten seeds of each legume were randomly selected to measure their length (L), width (W), and thickness (T) with help of digital vernier caliper (Model: Labin). Mean values were utilized for subsequent calculations (Mohsenin, 1986) [15].
- **Geometric Mean Diameter (Dg):** The geometric mean diameter, reflecting the mean seed size, was calculated as follows: (Mohsenin, 1986) [15].

$$Dg = \sqrt[3]{(L \times W \times T)}$$

Where,

L=Length

W=Width

T=Thickness

Sphericity (Φ): Sphericity (Φ), indicating how spherical the seeds are, was calculated as per the method given by (Mohsenin, 1986) [15].

$$\Phi = \frac{Dg}{L} \times 100$$

Where,

Dg=geometric mean diameter

L=length

Bulk Density (ρ_t) (g/cm³): Bulk density was measured by placing 10g of seeds into a 100 mL graduated cylinder without tapping and weighing them on the analytical balance. Bulk density was computed as per standard method (Singh and Goswami, 1996) [24].

$$\text{Bulk Density} = \frac{\text{Mass of seeds}}{\text{Volume of seeds}}$$

True Density (ρ_b), (g/cm³): True density was determined by the toluene displacement technique. Ten grams of seeds was added to a 100 mL measuring cylinder filled with toluene (a non-polar solvent that does not penetrate the seeds), and the volume displacement was recorded. True density was computed as per standard method (Sacilik *et al.*, 2003) [23].

$$\text{True Density} = \frac{\text{Mass of seeds}}{\text{Volume of toluene displaced}}$$

Porosity (ε) (%): Porosity, that is a measure of void space in a bulk seed sample, was determined from the formula. (Sacilik *et al.*, 2003) [23].

$$\text{Porosity}(\epsilon) = \frac{(\rho_t - \rho_b)}{\rho_t} \times 100$$

Where,

ρ_t=true density

ρ_b=bulk density

2.4 Chemical Analysis

Moisture Content: Moisture level was measured using the oven drying method. About 5g of sample was taken on a

pre-weighted moisture dish and dried under hot air in an oven (Model: i-therm AI-7981) at a temperature of $105 \pm 2^\circ\text{C}$ for 4-6 h until constant weight was obtained. Moisture content (%) was estimated as: (AOAC, 2019) ^[2].

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Crude Protein Content: Protein was estimated by the Kjeldahl method. A portion of approximately 1g of finely powdered sample was digested with concentrated H_2SO_4 in a Kjeldahl digestion unit (Model: Tulin Kjeltron). The digest was then distilled and titrated for nitrogen content, and it was calculated to protein by multiplying with a factor of 6.25: (AOAC, 2019) ^[2].

$$\text{Nitrogen (\%)} = \frac{(V_{\text{sample}} - V_{\text{blank}}) \times N \times 1.4007}{w}$$

Where,

- V_{sample} = Volume of acid used for sample titration (mL)
- V_{blank} = Volume of acid used for blank (mL)
- N = Normality of acid
- W = Weight of sample (g)
- 1.4007 is a constant derived from molar mass of nitrogen (14.007 g/mol) and unit conversions.

Crude Fat Content: Crude fat was analyzed by Soxhlet extraction. About 3-5 g of dried material was put in a thimble and extracted with petroleum ether (boiling point $40-60^\circ\text{C}$) for 6-8 hours in a Soxhlet apparatus (Model: Tulin SOXTRON Sox-4). The solvent was evaporated after extraction, and the fat content was estimated by weight difference. (AOAC, 2019) ^[2].

$$\text{Crude Fat (\%)} = \frac{\text{Weight of extracted fat}}{\text{Weight of sample}} \times 100$$

Crude Fiber Content: Crude fiber was estimated by acid-base digestion method. About 2g of defatted material was boiled with 1.25% sulfuric acid followed by boiling with 1.25% sodium hydroxide solutions. The residue was filtered, dried, and incinerated in a muffle furnace (Model: Tulin FIBROTRON FRB-2) at 550°C . Crude fiber was estimated by difference between residue weight before and after ashing. (AOAC, 2019) ^[2].

$$\text{Crude Fiber (\%)} = \frac{\text{Weight of residue before ashing} - \text{Weight after ashing}}{\text{Weight of sample}} \times 100$$

Mineral (Ash) Content: The overall mineral content was estimated by ash analysis. Around 2-3 g of sample was transferred to a pre-weighted crucible and incinerated in a muffle furnace at 550°C for 5-6 hours until the production of white ash. Ash content was stated as a percentage: (AOAC, 2019) ^[2].

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Initial weight of sample}} \times 100$$

2.4 Anti-nutritional factors

- **Phytic Acid Reduction:** Phytic acid content was determined using the Wade reagent method, which involves extracting the phytic acid with 0.2 N HCl,

followed by reaction with Wade reagent (a mixture of FeCl_3 and sulfosalicylic acid). The absorbance was measured at 500 nm using a UV-Vis spectrophotometer. Reduction (%) was calculated by comparing treated samples with the untreated control (Reddy *et al.*, 1982; Latta and Eskin, 1980) ^[21, 9].

- **Tannin Estimation:** Tannin content was measured using the Folin-Denis method. Extracts were prepared with 70% aqueous acetone, and the reaction was carried out with Folin-Denis reagent and sodium carbonate. Absorbance was read at 700 nm. The percentage reduction was calculated relative to the control (Price *et al.*, 1978) ^[19].
- **Trypsin Inhibitor Activity (TIA):** Trypsin inhibitor activity was assessed based on enzyme-substrate reaction using BAPNA ($\text{N}\alpha$ -Benzoyl-DL-arginine-p-nitroanilide) as the substrate. The decrease in absorbance at 410 nm indicated inhibitor activity. Results were expressed in TIU (Trypsin Inhibitory Units), and reduction percentage was calculated accordingly (Kakade *et al.*, 1974) ^[7].
- **Lectin Activity:** Lectin content was estimated using hemagglutination assay. Serial dilutions of the legume extract were mixed with human or animal erythrocytes to determine the minimum concentration that causes visible agglutination. The reduction in lectin activity was expressed as a percentage compared to the control (Liener *et al.*, 1980) ^[10].
- **Saponin Content:** Saponins were quantified using the spectrophotometric method involving vanillin-sulfuric acid reaction. Extracts were reacted with vanillin and sulfuric acid, and absorbance was measured at 544 nm. The reduction in saponin content was calculated in percentage terms in comparison to the untreated control (Obadoni and Ochuko, 2001) ^[18].

2.6 Sensory Evaluation

Sensory evaluation of the treated legumes as well as legume snacks formulations was undertaken using the 9-point Hedonic scale, comprising of scores designated between 1 = dislike extremely and 9 = like extremely. Semi-trained panel of 10 members assessed the sensory quality of the product to standardize the formulations on grounds of determining the consumer acceptability. The sensory properties analyzed were colour and appearance, flavour, texture, crispiness, taste, and overall acceptability (Meilgaard *et al.*, 2007) ^[13].

2.7 Storage Studies

Accelerated shelf-life test (ASLT) was performed to analyze the stability and storage properties of the legume-based snack under high-temperature conditions. Samples were sealed in laminated pouches and stored at a high temperature of $45 \pm 2^\circ\text{C}$ and relative humidity of $65 \pm 5\%$ for 30 days to mimic prolonged storage conditions. Measurements were taken at 0, 15, and 30 days to observe sensory properties (appearance, flavour, texture, crispiness, taste, and overall acceptability) and visible spoilage or moisture absorption.

Loss of crispness and moisture uptake were the important parameters because they affect consumer acceptability and the product's deterioration in low-moisture snack foods. Accelerated conditions were selected for anticipating the shelf-life and the observation of initial changes in quality deterioration, hence enabling the fast evaluation of the

product within a small testing period (Manohar and Rao, 2000) [11].

2.8 Statistical Analysis

All experiments and evaluations in this study were conducted in triplicate to make the results more accurate and reliable. The data obtained was statistically analyzed using standard statistical methods described by Snedecor and Cochran (1990). Mean values and standard deviations were calculated for each parameter. To find out if the differences between treatments were meaningful, Duncan's Multiple Range Test was used, with probability set at $p \leq 0.05$.

3. Results and Discussion

3.1 Standardization of product making process:

Preliminary trials were conducted to standardize the soaking

medium for treatment of legumes. The legumes were separately soaked in varying levels of salt and alum solutions (0.2, 0.5 and 0.7%). The treated legumes were evaluated for their sensory properties and the results were recorded (Figure 2). Based on sensory evaluation scores it was clearly observed that among the concentrations, 0.2% salt whereas 0.5% alum found to be more suitable as a soaking medium for legumes compared to other concentrations, as indicated with the high scores for overall acceptability of peanut (7.8 and 6.8, respectively), green gram (7.7 and 7.1, respectively), cowpea (7.6 and 6.9, respectively), field bean (7.9 and 7.2, respectively), horse gram (7.6 and 7.0, respectively) and soybean (7.8 and 7.1, respectively). The high concentration of salt affected the taste and crispiness of the product and improved colour as well as texture.

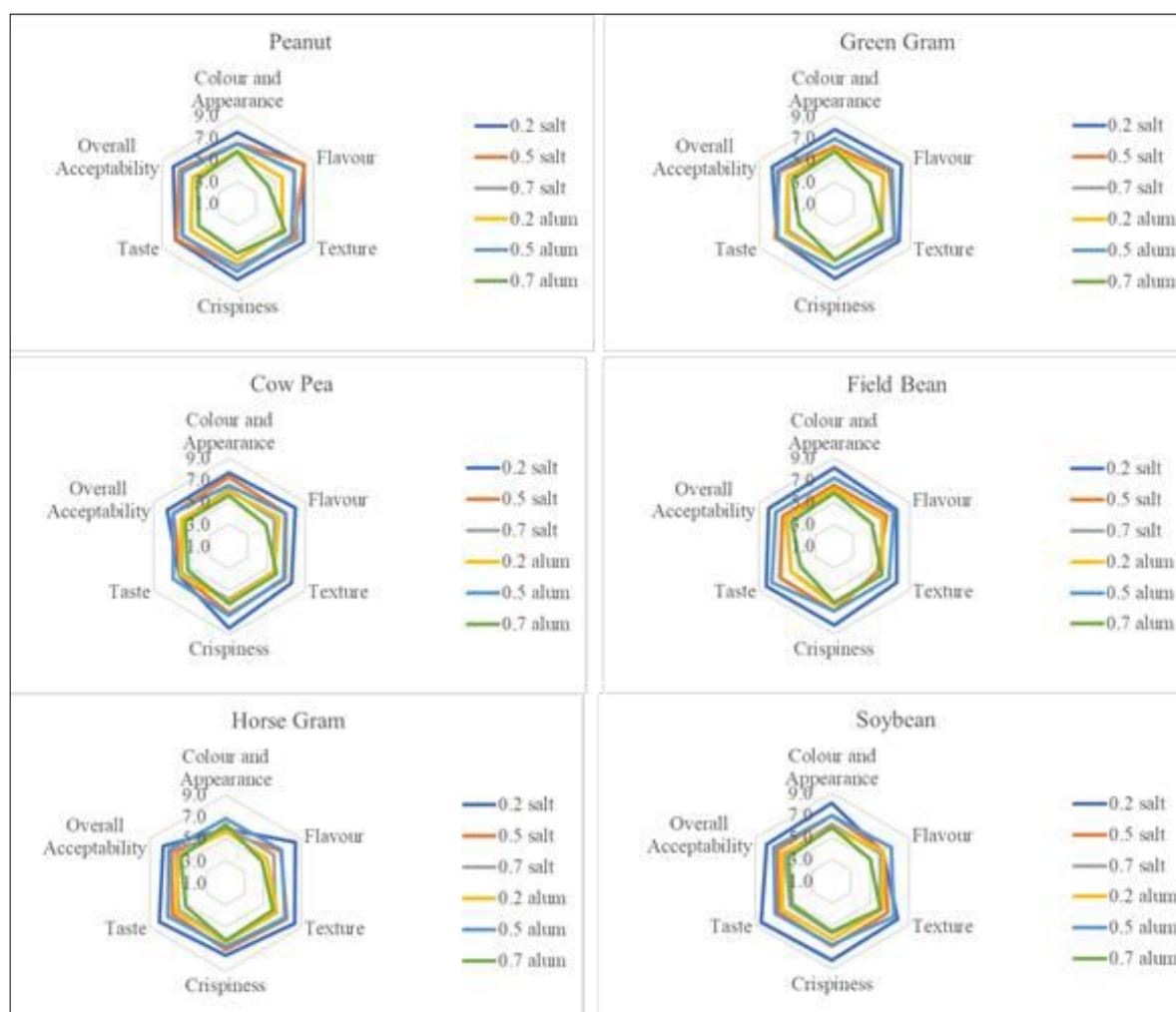


Fig 2: Sensory analysis of processed legumes

3.2 Physical analysis

3.2.1 Weight

Based on the data comparing the weight of 100 seeds under different treatments 0.2% salt, 0.5% alum, and a combination of both (0.2% salt + 0.5% alum), distinct trends emerge across legumes and processing methods. It is clearly observed from table no. 1, that soaking resulted in increase in the weight of seeds due to imbibition of water in the dry seeds making the seeds rehydrated (Bewley and Black, 1994) [3]. After germination, the weights of seeds slightly decreased as germination is an exothermic process, causing loss of moisture due to internal heat (Mayer and Poljakoff-

Mayber, 1989) [12]. Whereas roasting being the heat treatment, caused great reduction in the weights of seeds due to evaporation of moisture at high temperature (Tiwari, *et al.*, 2011) [28]. In general, the combination treatment (0.2% salt + 0.5% alum) often resulted in a slight increase in seed weight compared to individual treatments, particularly in peanuts and green gram during soaking and germination. For instance, peanut seeds showed a marginal increase from 82.98 g (0.2% salt) and 82.83 g (0.5% alum) to 83.35 g under the combined treatment during soaking. Similarly, green gram had a progressive increase in weight across treatments in both soaking and germination. However, in

roasting, the trend was less consistent; for example, green gram seed weight slightly declined under the combined treatment, while in Cowpea and Field bean, roasting showed more notable weight increases under the combination treatment. These variations suggest that while combined salt and alum treatments may enhance hydration and possibly preserve or enhance mass in some legumes and processes, the effect is not uniform across all types and conditions.

3.2.2 Length, width, thickness, geometric mean diameter, sphericity

The influence of different treatment concentrations (0.2% salt, 0.5% alum, and a combination of 0.2% salt with 0.5% alum) on the physical dimensional properties of legumes was evaluated in terms of length, width, thickness, geometric mean diameter, and sphericity. In peanuts, the 0.5% alum treatment generally resulted in marginal increases across all measured dimensions compared to the 0.2% salt treatment, indicating a potential enhancement in water uptake or structural preservation. The combined treatment (0.2% salt + 0.5% alum) further supported these observations, particularly with slight increases in geometric mean diameter and sphericity, suggesting a synergistic effect of alum and salt. For green gram, the physical parameters remained relatively stable across treatments,

with only minor variations noted. Notably, the combined treatment yielded a modest increase in sphericity compared to individual treatments. These findings indicate that the combination of alum and salt may contribute to improved retention of physical integrity in legumes during processing, potentially enhancing their quality and functionality in food applications.

3.2.3 Bulk density, true density, porosity

The bulk density, true density, and porosity of legumes are significantly influenced by soaking, germination, and roasting treatments. Soaking generally maintains or slightly increases bulk density due to water absorption, while true density remains relatively stable or shows marginal variation. Germination tends to slightly reduce both densities as enzymatic activity alters the seed structure. Roasting, in contrast, significantly reduces bulk density across all legumes, likely due to moisture loss and puffing, while true density also drops, reflecting structural degradation. Porosity tends to increase with roasting, indicating greater internal voids, while germination and soaking show moderate changes. These trends suggest roasting causes the most drastic physical changes, followed by germination and soaking (Mohsenin, 1986; Kulthe *et al.*, 2025) [15, 8].

Table 1: Effects of soaking treatment on the physical properties of the legumes

Properties	Soaking Medium	Peanut	Green gram	Cowpea	Field bean	Horse gram	Soybean
Weight (100 seeds, g)	0.2 Salt	82.98±0.48 ^a	10.23±0.09 ^b	26.83±0.32 ^a	44.10±0.77 ^a	8.44±0.04 ^a	37.44±0.98 ^a
	0.5% alum	82.83±0.84 ^a	10.37±0.22 ^a	26.66±0.29 ^a	44.31±0.58 ^a	8.42±0.19 ^a	37.77±0.51 ^a
	0.2salt+0.5 alum	83.35±0.53 ^b	10.51±0.22 ^a	26.50±0.48 ^b	44.00±0.51 ^a	8.32±0.09 ^b	37.31±0.30 ^a
Length (mm)	0.2 Salt	16.66±0.19 ^a	7.25±0.05 ^a	11.07±0.06 ^a	15.87±0.16 ^b	6.75±0.07 ^a	10.44±0.06 ^a
	0.5% alum	16.76±0.18 ^a	7.17±0.06 ^b	11.03±0.11 ^a	15.95±0.13 ^b	6.70±0.05 ^a	10.52±0.13 ^a
	0.2salt+0.5 alum	16.53±0.14 ^b	7.16±0.05 ^b	11.10±0.09 ^a	16.10±0.04 ^a	6.72±0.04 ^a	10.48±0.11 ^a
Width (mm)	0.2 Salt	8.42±0.03 ^a	5.28±0.04 ^a	8.72±0.08 ^a	11.17±0.10 ^a	5.25±0.04 ^a	8.87±0.03 ^a
	0.5% alum	8.42±0.07 ^a	5.20±0.01 ^b	8.72±0.02 ^a	11.17±0.12 ^a	5.21±0.06 ^a	8.81±0.08 ^b
	0.2salt+0.5 alum	8.34±0.07 ^b	5.27±0.06 ^a	8.70±0.09 ^a	11.20±0.07 ^a	5.25±0.04 ^a	8.85±0.08 ^a
Thickness (mm)	0.2 Salt	6.70±0.08 ^a	4.61±0.07 ^a	7.15±0.09 ^a	8.77±0.07 ^b	3.76±0.07 ^a	8.11±0.04 ^a
	0.5% alum	6.73±0.09 ^a	4.56±0.04 ^a	7.17±0.10 ^a	8.73±0.08 ^b	3.74±0.02 ^b	8.05±0.09 ^b
	0.2salt+0.5 alum	6.73±0.12 ^a	4.61±0.07 ^a	7.17±0.05 ^a	8.86±0.06 ^a	3.78±0.02 ^a	8.11±0.01 ^a
Geometric Mean Diameter (mm)	0.2 Salt	9.79±0.08 ^a	5.61±0.05 ^a	8.84±0.02 ^a	11.58±0.08 ^b	5.11±0.00 ^a	9.09±0.02 ^a
	0.5% alum	9.83±0.07 ^a	5.54±0.03 ^b	8.84±0.01 ^a	11.59±0.04 ^b	5.07±0.02 ^b	9.07±0.05 ^a
	0.2salt+0.5 alum	9.75±0.05 ^b	5.58±0.02 ^a	8.85±0.06 ^a	11.69±0.04 ^a	5.11±0.01 ^a	9.09±0.06 ^a
Sphericity (%)	0.2 Salt	58.80±0.34 ^a	77.38±0.27 ^b	79.82±0.55 ^a	73.00±0.53 ^a	75.66±0.81 ^a	87.06±0.40 ^a
	0.5% alum	58.64±0.16 ^b	77.32±0.32 ^b	80.08±0.89 ^a	72.65±0.53 ^a	75.68±0.49 ^a	86.23±0.67 ^b
	0.2salt+0.5 alum	59.01±0.29 ^a	77.97±0.26 ^a	79.67±0.20 ^a	72.61±0.40 ^a	75.99±0.54 ^a	86.77±0.49 ^a
Bulk Density (g/cm ³)	0.2 Salt	0.74±0.04 ^a	1.10±0.02 ^a	1.23±0.03 ^a	1.07±0.04 ^a	1.19±0.03 ^b	1.26±0.04 ^a
	0.5% alum	0.76±0.04 ^a	1.10±0.03 ^a	1.19±0.02 ^b	1.08±0.05 ^a	1.24±0.04 ^a	1.28±0.03 ^a
	0.2salt+0.5 alum	0.75±0.04 ^a	1.06±0.03 ^b	1.20±0.05 ^a	1.07±0.01 ^a	1.18±0.04 ^b	1.23±0.05 ^b
True Density (g/cm ³)	0.2 Salt	1.56±0.02 ^a	1.63±0.04 ^b	2.05±0.04 ^a	2.04±0.01 ^a	1.94±0.04 ^a	2.02±0.03 ^a
	0.5% alum	1.56±0.04 ^a	1.68±0.04 ^a	2.07±0.07 ^a	2.06±0.02 ^a	1.94±0.07 ^a	1.99±0.04 ^a
	0.2salt+0.5 alum	1.58±0.02 ^a	1.68±0.01 ^a	2.06±0.01 ^a	2.02±0.03 ^b	1.90±0.07 ^a	2.04±0.06 ^a
Porosity (%)	0.2 Salt	52.89±0.26 ^a	32.13±0.76 ^c	40.16±0.13 ^c	47.47±0.05 ^a	38.56±0.40 ^a	37.62±0.61 ^b
	0.5% alum	51.56±0.95 ^b	34.72±0.86 ^b	42.57±0.57 ^a	47.46±0.66 ^a	36.16±0.62 ^c	35.83±0.53 ^c
	0.2salt+0.5 alum	52.32±0.38 ^a	36.98±0.35 ^a	41.82±0.15 ^b	47.12±0.23 ^a	37.83±0.86 ^b	39.64±0.24 ^a

Each value is average of three determinations±standard deviation.

Values not sharing a common superscript letter(s) in a column for each property are significantly different at $p < 0.05$ as assessed by Duncan's Multiple Range test

Table 2: Effects of germination on the physical properties of the legumes

Properties	Soaking Medium	Peanut	Green gram	Cowpea	Field bean	Horse gram	Soybean
Weight (100 seeds, g)	0.2 Salt	80.80±0.11 ^a	10.21±0.01 ^b	24.35±0.49 ^a	42.68±0.33 ^b	7.8±0.16 ^a	33.87±0.38 ^b
	0.5% alum	78.54±0.63 ^c	10.32±0.20 ^a	24.21±0.22 ^a	42.48±0.22 ^b	7.84±0.18 ^a	34.17±0.89 ^a
	0.2salt+0.5 alum	78.81±0.16 ^a	10.43±0.14 ^a	24.51±0.35 ^a	43.1±0.36 ^a	7.79±0.08 ^a	34.34±0.22 ^a
Length (mm)	0.2 Salt	15.87±0.21 ^a	7.00±0.07 ^a	10.13±0.06 ^a	15.40±0.18 ^b	6.20±0.11 ^a	9.51±0.10 ^a
	0.5% alum	15.95±0.21 ^a	7.05±0.07 ^a	10.09±0.05 ^a	15.53±0.08 ^a	6.11±0.04 ^b	9.53±0.06 ^a
	0.2salt+0.5 alum	15.81±0.21 ^a	7.01±0.02 ^a	10.10±0.04 ^a	15.45±0.10 ^a	6.21±0.03 ^a	9.49±0.10 ^a
Width (mm)	0.2 Salt	7.99±0.04 ^b	5.13±0.07 ^a	8.00±0.08 ^a	10.89±0.01 ^a	4.82±0.04 ^a	8.09±0.01 ^a
	0.5% alum	8.06±0.05 ^a	5.14±0.07 ^a	7.96±0.06 ^a	10.86±0.07 ^b	4.83±0.07 ^a	8.01±0.10 ^b
	0.2salt+0.5 alum	8.00±0.12 ^b	5.13±0.02 ^a	7.93±0.06 ^a	10.84±0.13 ^b	4.84±0.03 ^a	8.04±0.08 ^b
Thickness (mm)	0.2 Salt	6.35±0.08 ^a	4.51±0.04 ^a	6.53±0.05 ^a	8.56±0.02 ^b	3.50±0.07 ^a	7.41±0.04 ^a
	0.5% alum	6.41±0.09 ^a	4.50±0.03 ^a	6.53±0.04 ^a	8.64±0.07 ^a	3.49±0.03 ^a	7.35±0.01 ^b
	0.2salt+0.5 alum	6.37±0.06 ^a	4.51±0.04 ^a	6.47±0.05 ^b	8.51±0.04 ^c	3.42±0.02 ^b	7.33±0.06 ^c
Geometric Mean Diameter (mm)	0.2 Salt	9.30±0.02 ^b	5.45±0.05 ^a	8.09±0.03 ^a	11.28±0.05 ^b	4.71±0.07 ^a	8.29±0.04 ^a
	0.5% alum	9.37±0.04 ^a	5.46±0.05 ^a	8.07±0.03 ^a	11.33±0.02 ^a	4.69±0.02 ^a	8.25±0.03 ^a
	0.2salt+0.5 alum	9.31±0.07 ^b	5.46±0.03 ^a	8.03±0.02 ^b	11.25±0.08 ^b	4.69±0.03 ^a	8.24±0.00 ^b
Sphericity (%)	0.2 Salt	58.61±0.27 ^b	77.89±0.28 ^a	79.89±0.27 ^a	73.26±0.13 ^a	76.01±0.24 ^b	87.16±0.54 ^a
	0.5% alum	58.77±0.18 ^a	77.49±0.03 ^b	79.97±0.30 ^a	72.98±0.24 ^b	76.74±0.44 ^a	86.50±0.62 ^b
	0.2salt+0.5 alum	58.85±0.16 ^a	77.81±0.15 ^a	79.57±0.30 ^b	72.82±0.29 ^b	75.41±0.07 ^c	86.82±0.87 ^a
Bulk Density (g/cm ³)	0.2 Salt	0.74±0.02 ^a	1.07±0.03 ^a	1.11±0.05 ^a	1.03±0.02 ^a	1.12±0.05 ^a	1.13±0.05 ^b
	0.5% alum	0.72±0.02 ^a	1.05±0.04 ^a	1.11±0.03 ^a	1.03±0.03 ^a	1.14±0.05 ^a	1.17±0.03 ^a
	0.2salt+0.5 alum	0.72±0.03 ^a	1.05±0.03 ^a	1.09±0.04 ^a	1.05±0.02 ^a	1.09±0.02 ^a	1.15±0.04 ^a
True Density (g/cm ³)	0.2 Salt	1.47±0.05 ^a	1.64±0.01 ^a	1.91±0.06 ^b	1.95±0.07 ^a	1.79±0.01 ^a	1.83±0.03 ^a
	0.5% alum	1.49±0.02 ^a	1.64±0.03 ^a	1.94±0.01 ^a	1.99±0.01 ^a	1.74±0.03 ^b	1.85±0.08 ^a
	0.2salt+0.5 alum	1.50±0.05 ^a	1.60±0.03 ^b	1.92±0.04 ^b	1.99±0.06 ^a	1.77±0.07 ^b	1.83±0.01 ^a
Porosity (%)	0.2 Salt	49.63±0.56 ^c	34.55±0.24 ^c	42.07±0.25 ^c	47.31±0.17 ^b	37.73±0.68 ^a	38.33±0.40 ^a
	0.5% alum	51.42±0.80 ^b	35.98±0.83 ^a	42.67±0.39 ^b	48.08±0.14 ^a	34.75±0.37 ^b	36.68±0.68 ^b
	0.2salt+0.5 alum	52.00±0.35 ^a	34.72±0.15 ^b	43.06±0.48 ^a	47.32±0.48 ^b	38.61±0.98 ^a	37.04±0.63 ^a

Each value is average of three determinations±standard deviation.

Values not sharing a common superscript letter(s) in a column for each property are significantly different at $p<0.05$ as assessed by Duncan's Multiple Range test

Table 3: Effects of roasting on the physical properties of the legumes

Properties	Legumes	Peanut	Green gram	Cowpea	Field bean	Horse gram	Soybean
Weight (100 seeds, g)	0.2 Salt	49.49±0.12 ^a	4.98±0.19 ^a	12.22±0.54 ^b	20.74±0.08 ^a	4.23±0.13 ^a	16.89±0.32 ^a
	0.5% alum	48.67±0.21 ^c	4.98±0.12 ^a	12.53±0.40 ^b	20.14±0.23 ^c	4.39±0.21 ^a	16.04±0.39 ^c
	0.2salt+0.5 alum	49.34±0.26 ^b	4.83±0.14 ^b	13.08±0.20 ^a	20.54±0.16 ^b	4.28±0.17 ^a	16.23±0.15 ^b
Length (mm)	0.2 Salt	13.65±0.05 ^a	4.73±0.09 ^a	7.28±0.01 ^a	10.28±0.10 ^a	4.77±0.04 ^b	6.43±0.07 ^a
	0.5% alum	13.73±0.17 ^a	4.75±0.13 ^a	7.25±0.14 ^b	10.40±0.12 ^a	4.83±0.05 ^a	6.39±0.09 ^a
	0.2salt+0.5 alum	13.42±0.14 ^b	4.72±0.13 ^a	7.21±0.08 ^b	10.26±0.06 ^b	4.78±0.10 ^a	6.37±0.14 ^a
Width (mm)	0.2 Salt	6.87±0.11 ^a	3.42±0.11 ^a	5.57±0.01 ^a	7.34±0.14 ^a	3.73±0.06 ^a	5.43±0.07 ^a
	0.5% alum	6.88±0.12 ^a	3.41±0.06 ^a	5.66±0.14 ^a	7.15±0.10 ^b	3.71±0.06 ^a	5.45±0.13 ^a
	0.2salt+0.5 alum	6.80±0.14 ^a	3.41±0.07 ^a	5.62±0.10 ^a	7.25±0.10 ^a	3.72±0.04 ^a	5.38±0.03 ^a
Thickness (mm)	0.2 Salt	5.48±0.11 ^a	3.00±0.03 ^b	4.62±0.07 ^b	5.78±0.08 ^a	2.65±0.01 ^b	4.97±0.06 ^a
	0.5% alum	5.39±0.06 ^b	3.04±0.02 ^a	4.57±0.01 ^b	5.67±0.08 ^b	2.74±0.06 ^a	5.00±0.09 ^a
	0.2salt+0.5 alum	5.52±0.05 ^a	3.04±0.01 ^a	4.69±0.04 ^a	5.71±0.10 ^a	2.71±0.06 ^a	4.87±0.03 ^b
Geometric Mean Diameter (mm)	0.2 Salt	8.01±0.01 ^a	3.65±0.04 ^a	5.72±0.02 ^a	7.58±0.06 ^a	3.61±0.02 ^b	5.58±0.03 ^a
	0.5% alum	7.98±0.02 ^b	3.66±0.01 ^a	5.72±0.07 ^a	7.50±0.03 ^b	3.66±0.04 ^a	5.58±0.02 ^a
	0.2salt+0.5 alum	7.96±0.03 ^b	3.66±0.02 ^a	5.75±0.03 ^a	7.51±0.08 ^b	3.64±0.04 ^a	5.51±0.05 ^b
Sphericity (%)	0.2 Salt	58.66±0.24 ^b	77.18±0.17 ^b	78.57±0.32 ^c	73.78±0.23 ^a	75.77±0.18 ^c	86.74±0.16 ^b
	0.5% alum	58.16±0.12 ^c	77.11±0.21 ^b	78.91±0.25 ^b	72.10±0.21 ^c	75.86±0.28 ^b	87.23±0.23 ^a
	0.2salt+0.5 alum	59.30±0.13 ^a	77.49±0.15 ^a	79.75±0.16 ^a	73.27±0.18 ^b	76.18±0.21 ^a	86.43±0.22 ^c
Bulk Density (g/cm ³)	0.2 Salt	0.61±0.03 ^a	0.70±0.05 ^b	0.78±0.04 ^a	0.69±0.03 ^b	0.89±0.02 ^a	0.78±0.02 ^a
	0.5% alum	0.62±0.02 ^a	0.69±0.02 ^b	0.77±0.02 ^a	0.71±0.01 ^a	0.87±0.06 ^a	0.77±0.02 ^a
	0.2salt+0.5 alum	0.60±0.04 ^b	0.73±0.02 ^a	0.77±0.04 ^a	0.72±0.02 ^a	0.84±0.02 ^b	0.75±0.03 ^b
True Density (g/cm ³)	0.2 Salt	1.28±0.01 ^a	1.09±0.02 ^a	1.34±0.03 ^b	1.31±0.03 ^a	1.41±0.01 ^a	1.26±0.02 ^a
	0.5% alum	1.26±0.03 ^b	1.10±0.01 ^a	1.38±0.03 ^a	1.32±0.05 ^a	1.38±0.02 ^b	1.23±0.01 ^b
	0.2salt+0.5 alum	1.25±0.01 ^b	1.09±0.03 ^a	1.33±0.03 ^b	1.32±0.03 ^a	1.39±0.01 ^b	1.24±0.02 ^a
Porosity (%)	0.2 Salt	52.21±0.15 ^a	36.24±0.13 ^b	41.84±0.12 ^c	47.32±0.12 ^c	36.70±0.17 ^b	38.02±0.15 ^b
	0.5% alum	50.71±0.10 ^b	37.35±0.18 ^a	43.91±0.15 ^a	45.67±0.07 ^a	36.50±0.12 ^c	37.38±0.18 ^c
	0.2salt+0.5 alum	52.27±0.09 ^a	33.13±0.22 ^c	42.25±0.19 ^b	45.34±0.11 ^b	39.57±0.13 ^a	39.52±0.17 ^a

Each value is average of three determinations±standard deviation.

Values not sharing a common superscript letter(s) in a column for each property are significantly different at $p<0.05$ as assessed by Duncan's Multiple Range test

3.3 Chemical analysis

The data demonstrates how the different concentrations influence the nutritional composition of the six legumes. Moisture content generally showed a slight increase with the

addition of alum, especially in field bean and cowpea, while the combination treatment had a moderate effect. Protein levels remained relatively stable across treatments, with minor increases under 0.5% alum, particularly in peanut and

horse gram. Fat content exhibited minimal variation, although slight increases were noted with alum and combination treatments in cowpea and soybean. Fiber content remained consistent throughout, with slight increases in soybean and cowpea under combination treatment. Mineral content showed minor fluctuations, with a trend of increase under 0.5% alum and combination treatment especially in soybean and field bean.

Carbohydrate content generally remained stable or decreased slightly in most samples with combination treatment, especially in soybean and field bean. Overall, the combination of salt and alum had variable effects across different nutrients and legumes, suggesting ingredient specific interactions with these substances. (Agoreyo, *et al.*, 2011; Kulthe *et al.*, 2025) [8].

Table 4: Effects of processing on the chemical properties of the legumes

Properties	Ingredient	Peanut	Green gram	Cowpea	Field bean	Horse gram	Soybean
Moisture	0.2 Salt	4.23±0.05 ^c	6.47±0.05 ^a	5.60±0.06 ^b	5.63±0.02 ^b	2.23±0.05 ^c	4.43±0.05 ^b
	0.5% alum	4.53±0.03 ^a	6.37±0.06 ^b	5.73±0.02 ^a	5.83±0.02 ^a	2.47±0.02 ^b	4.20±0.06 ^c
	0.2salt+0.5 alum	4.43±0.05 ^b	6.47±0.05 ^a	5.37±0.03 ^c	5.60±0.02 ^c	2.63±0.09 ^a	4.47±0.02 ^a
Protein	0.2 Salt	27.04±0.05 ^c	25.06±0.07 ^b	16.22±0.04 ^c	18.42±0.02 ^a	17.07±0.03 ^b	25.45±0.01 ^c
	0.5% alum	27.90±0.07 ^a	25.40±0.04 ^a	16.53±0.02 ^a	18.30±0.02 ^c	17.60±0.03 ^a	25.53±0.04 ^b
	0.2salt+0.5 alum	27.30±0.06 ^b	25.43±0.05 ^a	16.33±0.05 ^b	18.37±0.03 ^b	17.60±0.02 ^a	25.90±0.01 ^a
Fat	0.2 Salt	5.34±0.04 ^a	1.13±0.02 ^c	2.15±0.03 ^c	1.36±0.03 ^b	0.45±0.04 ^c	1.29±0.03 ^c
	0.5% alum	5.33±0.03 ^a	1.70±0.03 ^a	2.30±0.02 ^b	1.30±0.02 ^c	0.73±0.03 ^a	1.53±0.01 ^b
	0.2salt+0.5 alum	5.33±0.02 ^a	1.33±0.06 ^b	2.37±0.04 ^a	1.80±0.02 ^a	0.50±0.04 ^b	1.57±0.03 ^a
Fiber	0.2 Salt	8.30±0.03 ^b	8.43±0.02 ^b	8.27±0.05 ^c	7.40±0.02 ^b	5.63±0.03 ^a	9.53±0.02 ^b
	0.5% alum	8.37±0.02 ^a	8.57±0.04 ^a	8.20±0.02 ^b	7.17±0.06 ^c	5.53±0.02 ^b	9.73±0.05 ^a
	0.2salt+0.5 alum	8.40±0.04 ^a	8.23±0.02 ^c	8.57±0.03 ^a	7.57±0.03 ^a	5.63±0.03 ^a	9.73±0.09 ^a
Mineral	0.2 Salt	3.33±0.04 ^b	5.30±0.06 ^c	3.45±0.06 ^c	3.17±0.05 ^c	2.15±0.07 ^c	3.32±0.03 ^b
	0.5% alum	3.53±0.04 ^a	5.37±0.03 ^b	3.67±0.09 ^a	3.40±0.06 ^b	2.23±0.06 ^b	3.13±0.02 ^c
	0.2salt+0.5 alum	3.33±0.09 ^b	5.70±0.02 ^a	3.50±0.04 ^b	3.80±0.09 ^a	2.50±0.07 ^a	3.43±0.05 ^a
Carbohydrates	0.2 Salt	51.76±0.31 ^a	53.62±0.93 ^a	64.32±0.77 ^a	64.02±0.13 ^a	72.11±0.98 ^b	55.98±0.29 ^a
	0.5% alum	50.33±0.74 ^c	52.60±0.79 ^b	63.57±0.15 ^a	64.00±0.62 ^a	71.17±0.29 ^a	55.87±0.45 ^a
	0.2salt+0.5 alum	51.20±0.46 ^b	52.83±0.12 ^a	63.87±0.60 ^a	62.87±0.90 ^a	71.13±0.55 ^a	54.90±0.56 ^b

Each value is average of three determinations±standard deviation.

Values not sharing a common superscript letter(s) in a column for each property are significantly different at $p<0.05$ as assessed by Duncan's Multiple Range test

3.4 Anti-nutritional factors

The application of varying salt and alum concentrations affected the reduction of anti-nutritional components in all six legumes examined. 0.5% alum treatment recorded more reductions in phytic acid, tannins, trypsin inhibitors, lectins, and saponins than 0.2% salt treatment alone. The combination treatment (0.2% salt + 0.5% alum) had the highest overall reduction for all anti-nutritional factors in every legume, suggesting synergism. For example, in soybean, the combined treatment decreased phytic acid by

33.77%, tannins by 37.68%, trypsin inhibitors by 31.35%, lectins by 27.82%, and saponins by 23.88%, much greater than decreases with single treatments. These trends were also observed in other legumes field bean and horse gram, in which combination treatments produced above 30% decreases for most anti-nutrients. These findings indicate that using a combined treatment of alum and salt is more efficient in reducing anti-nutritional compounds, thus possibly enhancing the nutritional quality and digestibility of legumes (Kulthe *et al.*, 2025) [8].

Table 5: Anti-nutritional factors

Properties	Treatment	Peanut	Green gram	Cowpea	Field bean	Horse gram	Soybean
Phytic Acid Reduction (%)	0.2% Salt	14.29±0.37 ^c	14.82±0.18 ^c	16.54±0.43 ^c	17.86±0.22 ^c	18.52±0.42 ^c	18.85±0.45 ^c
	0.5% Alum	20.17±0.29 ^b	21.75±0.37 ^b	22.80±0.35 ^b	24.80±0.45 ^b	25.44±0.10 ^b	26.45±0.36 ^b
	0.2% Salt + 0.5% Alum	29.05±0.13 ^a	28.77±0.12 ^a	30.19±0.40 ^a	31.80±0.03 ^a	32.17±0.40 ^a	33.77±0.09 ^a
Tannin Reduction (%)	0.2% Salt	16.04±0.30 ^c	17.03±0.32 ^c	18.19±0.38 ^c	19.54±0.21 ^c	20.22±0.40 ^c	21.18±0.27 ^c
	0.5% Alum	23.18±0.44 ^b	23.84±0.52 ^b	25.54±0.39 ^b	26.32±0.26 ^b	27.09±0.39 ^b	29.01±0.30 ^b
	0.2% Salt + 0.5% Alum	31.92±0.48 ^a	32.70±0.36 ^a	33.45±0.22 ^a	34.97±0.42 ^a	35.13±0.23 ^a	37.68±0.08 ^a
Trypsin Inhibitor Reduction (%)	0.2% Salt	11.62±0.50 ^c	12.19±0.29 ^c	12.86±0.38 ^c	14.54±0.22 ^c	15.27±0.10 ^c	16.63±0.37 ^c
	0.5% Alum	17.03±0.32 ^b	18.45±0.36 ^b	19.49±0.44 ^b	21.18±0.27 ^b	21.92±0.33 ^b	23.37±0.33 ^b
	0.2% Salt + 0.5% Alum	24.88±0.23 ^a	26.05±0.40 ^a	27.07±0.2 ^a	27.65±0.08 ^a	29.35±0.44 ^a	31.35±0.30 ^a
Lectin Reduction (%)	0.2% Salt	9.33±0.29 ^c	10.79±0.04 ^c	11.05±0.27 ^c	12.01±0.27 ^c	12.55±0.31 ^c	13.35±0.04 ^c
	0.5% Alum	14.13±0.14 ^b	15.95±0.31 ^c	16.95±0.45 ^b	17.78±0.36 ^b	18.33±0.08 ^b	20.61±0.42 ^b
	0.2% Salt + 0.5% Alum	21.61±0.46 ^a	22.16±0.17 ^a	23.68±0.07 ^a	24.05±0.05 ^a	26.43±0.08 ^a	27.82±0.3 ^a
Saponin Reduction (%)	0.2% Salt	7.85±0.45 ^c	8.94±0.37 ^c	9.53±0.38 ^c	10.17±0.29 ^c	10.45±0.37 ^c	11.45±0.43 ^c
	0.5% Alum	12.66±0.25 ^b	14.08±0.36 ^b	14.76±0.32 ^b	14.98±0.37 ^b	15.90±0.43 ^b	17.93±0.21 ^b
	0.2% Salt + 0.5% Alum	18.25±0.32 ^a	19.69±0.04 ^a	20.37±0.50 ^a	20.94±0.38 ^a	22.56±0.37 ^a	23.88±0.46 ^a

Each value is average of three determinations±standard deviation.

Values not sharing a common superscript letter(s) in a column for each property are significantly different at $p<0.05$ as assessed by Duncan's Multiple Range test

3.5 Product Standardization

Sensory analysis of two different formulations identified that formulation 2 was far more acceptable in terms of all parameters except one against formulation 1. Formulation 2 scored higher on flavour (8.0), texture (7.1), crispiness (7.7), taste (8.1) and overall acceptability (7.7) and showed better consumer preference. Conversely, formulation 1 ranked lower in texture (6.0), taste (6.5), and overall acceptability (6.9), although the two formulations were ranked equally in colour and appearance (7.1 and 7.3, respectively). The improved scores for formulation 2 indicate that adjustments in the ingredient formulation or processing conditions successfully improved product quality, which was more desirable to the panelists.

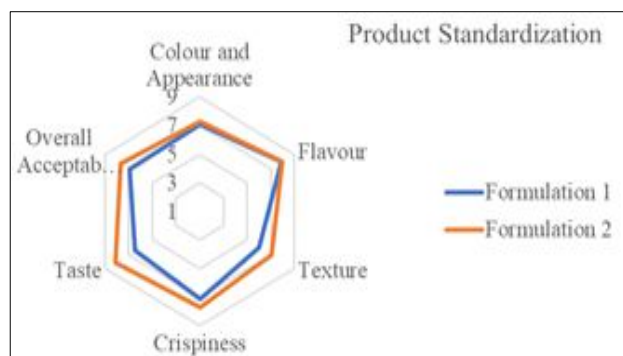


Fig 3: Sensory analysis for product formulation

3.6 Chemical analysis as per formulation

Chemical analysis of the two formulations showed minimal difference in nutritional content. Formulation 1 contained slightly more moisture ($4.74 \pm 0.36\%$) than formulation 2 ($4.48 \pm 0.30\%$), which would impact shelf life. Protein levels were slightly higher in formulation 2 ($22.22 \pm 0.13\%$) than in formulation 1 ($21.72 \pm 0.25\%$), reflecting modest improvement in nutritional content. Fat levels also experienced a slight rise in formulation 2 ($2.37 \pm 0.06\%$) compared to formulation 1 ($2.23 \pm 0.38\%$). Fibre and mineral levels were similar between the two formulations at $8.09 \pm 0.37\%$ and $8.01 \pm 0.49\%$ for fiber, and at $3.71 \pm 0.07\%$ and $3.52 \pm 0.06\%$ for minerals in Formulations 1 and 2, respectively. Carbohydrate content was also constant, at $59.35 \pm 0.19\%$ for Formulation 1 and $59.16 \pm 0.21\%$ for Formulation 2. These data imply that the two formulations were chemically equivalent with slight nutritional advantages seen in Formulation 2 (FAO, 2003; Kulthe *et al.*, 2025) [6, 8].

Table 6: Chemical analysis as per formulation

Properties	Formulation 1	Formulation 2
Moisture	4.74 ± 0.36^a	4.48 ± 0.30^a
Protein	21.72 ± 0.25^b	22.22 ± 0.13^a
Fat	2.23 ± 0.38^b	2.37 ± 0.06^a
Fiber	8.09 ± 0.37^a	8.01 ± 0.49^a
Mineral	3.71 ± 0.07^a	3.52 ± 0.06^b
Carbohydrates	59.35 ± 0.19^a	59.16 ± 0.21^a

Each value is average of three determinations $\pm$ standard deviation. Values not sharing a common superscript letter(s) in a row are significantly different at $p < 0.05$ as assessed by Duncan's Multiple Range test

3.7 Anti-nutritional factors based on formulation:

The anti-nutritional evaluation of the two formulations shows that Phytic acid reduction in Formulation 2 was

slightly more at $30.91 \pm 0.06\%$, whereas in Formulation 1 it was $30.7 \pm 0.05\%$. Likewise, trypsin inhibitor reduction was enhanced from $27.62 \pm 0.29\%$ in Formulation 1 to $27.85 \pm 0.27\%$ in Formulation 2, and lectin reduction was boosted from $24.3 \pm 0.16\%$ to $24.74 \pm 0.32\%$. While tannin and saponin decreases were similar in both formulations, with Formulation 1 indicating a slightly greater reduction of tannin ($34.63 \pm 0.04\%$ vs. $34.44 \pm 0.47\%$) and Formulation 2 with a slightly reduced saponin decrease ($20.78 \pm 0.16\%$ vs. $21.07 \pm 0.19\%$), overall, Formulation 2 indicated a consistent pattern of slightly improved reduction of most anti-nutritional factors. This implies that Formulation 2 has a better option in terms of improved nutritional quality through better reduction of anti-nutrients. (Mubarak, 2005; Kulthe *et al.*, 2025) [8].

Table 5: Anti-nutritional factors based on formulation

Properties	Formulation 1	Formulation 2
Phytic Acid Reduction (%)	30.70 ± 0.05^b	30.91 ± 0.06^a
Tannin Reduction (%)	34.63 ± 0.04^a	34.44 ± 0.47^b
Trypsin Inhibitor Reduction (%)	27.62 ± 0.29^a	27.85 ± 0.27^a
Lectin Reduction (%)	24.30 ± 0.16^b	24.74 ± 0.32^a
Saponin Reduction (%)	21.07 ± 0.19^a	20.78 ± 0.16^b

Each value is average of three determinations $\pm$ standard deviation. Values not sharing a common superscript letter(s) in a row are significantly different at $p < 0.05$ as assessed by Duncan's Multiple Range test

3.8 Storage Studies

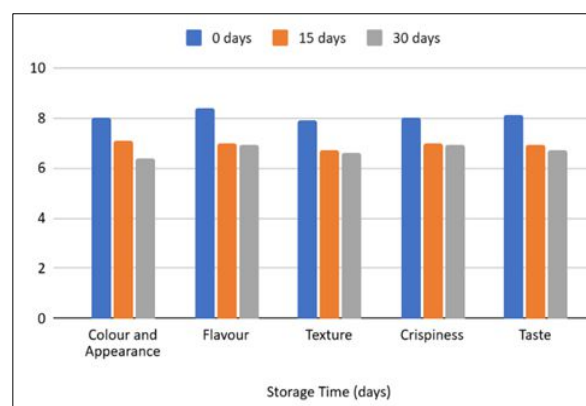


Fig 4: Accelerated storage study



Fig 5: Product in laminated pouch

As per the information derived from an accelerated storage test carried out for 30 days under high conditions of $45 \pm 2^\circ\text{C}$ temperature and $65 \pm 5\%$ relative humidity, the product showed negligible deterioration of sensory characteristics

like colour and appearance, flavour, texture, crispiness, taste, and general acceptability. The sensory scores at 0 days were high, with a general acceptability of 8.08, which reflects outstanding quality and freshness of the product. After 15 days, a slight reduction was seen in all the parameters, but the overall acceptability remained very high at 7.86. At 30 days, a minor further reduction lowered the overall acceptability to 7.7. These figures reflect good product stability under stress conditions for long-term storage. The deterioration in all quality attributes during 30 days is rather slow and restricted, with all ratings still well above 7.5, which is typically equivalent to a "liked very much" category on a 9-point hedonic scale. Based on the minor loss in quality during the 30-day test, it is reasonable to project that the product will be of acceptable sensory quality for not less than 6 months under standard storage conditions.

4. Conclusion

The results obtained from above research helped to develop a nutri rich, roasted legume based snack out of local legumes and minimal processing methods such as soaking, germination, and roasting with salt. The 0.2% salt and 0.5% alum combination was the most effective in enhancing sensory acceptance and minimizing anti-nutritional factors without compromising nutrient composition. Of the two formulations that were tried, formulation 2, with increased levels of peanut, field bean, horse gram, and soybean, showed superior sensory acceptability, better nutritional parameters, and maximum reduction of anti-nutrients. Accelerated storage studies also proved the sensory stability of the product for 30 days under stress. Overall, the snack is a promising, healthy, and shelf-stable option compared to traditional RTE snacks, especially in filling dietary needs in protein and fiber using sustainable, plant-based sources.

5. References

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