



Development and Nutritional Evaluation of Lentil-Wheat Composite Bread

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Abstract

The purpose of the present study was to formulate nutritionally enriched wheat bread using partial replacement of wheat flour with lentil flour and to assess the nutritional, physicochemical, textural, color and sensory properties of this bread. Wheat flour was substituted by lentil flour at the levels of 0, 5, 10, 15 and 20 to prepare composite breads. Increasing lentil flour incorporation significantly ($p < 0.05$) improved the nutritional profile of bread by increasing protein (10.60–13.45%), crude fiber (1.05–2.70%), ash (1.15–1.72%), gross energy (267–282 kcal/100 g), and mineral contents, while carbohydrate content decreased from 51.10 to 44.78%. Loaf weight increased, whereas loaf volume, specific volume, water activity, and color lightness (L^) decreased with increasing substitution levels. Texture profile analysis revealed increased hardness, gumminess, and chewiness, accompanied by reductions in springiness, cohesiveness, and resilience. Sensory evaluation showed that bread containing 10% lentil flour achieved the highest overall acceptability, while higher substitution levels slightly reduced sensory scores due to changes in texture and color. Overall, incorporation of lentil flour effectively enhanced the nutritional quality of wheat bread, and a 10% substitution level was identified as the optimum formulation, providing the best balance between nutritional improvement, technological quality, and consumer acceptability.*

1. Introduction

Bread is one of the most widely consumed staple foods worldwide and constitutes a major source of dietary carbohydrates, providing a significant proportion of daily energy intake. Conventional wheat bread, however, is nutritionally limited because wheat proteins are deficient in essential amino acids, particularly lysine, and refined wheat flour contains relatively low amounts of dietary fiber, minerals, and bioactive compounds. Increasing consumer awareness regarding healthy diets and the prevention of chronic diseases has generated considerable interest in developing functional bakery products with enhanced

nutritional value without compromising sensory quality (Boye *et al.*, 2010; Turfani *et al.*, 2017).

Among plant-based protein sources, lentil (*Lens culinaris* Medik.) has gained considerable attention because of its exceptional nutritional composition. Lentils contain approximately 22–30% high-quality protein, 11–18% dietary fiber, slowly digestible carbohydrates, essential minerals such as iron, zinc, magnesium and potassium, and numerous phytochemicals including phenolic acids, flavonoids and tannins that exhibit antioxidant activity. Furthermore, lentil proteins are particularly rich in lysine, which complement the amino acid profile of wheat proteins that are deficient in this

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essential amino acid, making cereal-legume combinations nutritionally superior to cereal-based products alone (Atudorei *et al.*, 2022; Moin *et al.*, 2025).

The incorporation of lentil flour into wheat-based bakery products represents an effective strategy to improve protein quality, dietary fiber content, mineral density and antioxidant capacity. Previous investigations have demonstrated that wheat-lentil composite bread contains substantially higher protein, ash, total dietary fiber and phenolic compounds than conventional wheat bread. Bread formulated with lentil flour has been reported to contain approximately 30% more protein, nearly twice the dietary fiber and mineral content, and significantly greater antioxidant activity due to increased concentrations of phenolic compounds and lignans. Such nutritional improvements may contribute to lowering the risk of obesity, cardiovascular diseases, type-2 diabetes and certain forms of cancer by promoting improved glycemic response, gut health and antioxidant defense (Carcea *et al.*, 2019; Turfani *et al.*, 2017).

Despite these nutritional advantages, the incorporation of legume flour presents technological challenges. Lentil flour dilutes the gluten network of wheat dough, potentially reducing dough strength, loaf volume and crumb softness. Studies indicate that while higher substitution levels may negatively affect bread quality, moderate incorporation (approximately 5–15%) generally produces acceptable bread with desirable sensory attributes while substantially improving nutritional value. The optimal substitution level depends on flour characteristics, particle size, processing conditions and bread formulation (Marchinia *et al.*, 2021; Turfani *et al.*, 2017).

Recent advances have further highlighted the importance of processing techniques such as germination, roasting and controlled milling in enhancing the functional properties of lentil flour. Germination has been shown to improve protein digestibility, increase antioxidant compounds, reduce antinutritional factors such as phytic acid, and improve dough rheology and bread quality. These findings suggest that processing methods can significantly influence both technological performance and nutritional functionality of composite bread, creating opportunities for further optimization (Atudorei *et al.*, 2022).

The growing prevalence of protein-energy malnutrition, micronutrient deficiencies and non-communicable diseases in developing countries further emphasizes the need for affordable nutrient-dense staple foods. Pakistan is among the

major wheat-consuming countries, where bread constitutes a significant portion of the daily diet. Simultaneously, lentils are traditionally cultivated and consumed in the country, making them an economical and locally available ingredient for food fortification. Developing lentil-wheat composite bread therefore represents a sustainable and cost-effective approach to improve nutritional security while promoting the utilization of locally produced pulses and supporting national food diversification strategies (Boye *et al.*, 2010; Moin *et al.*, 2025).

Although several international studies have investigated composite bread containing legumes, comprehensive information integrating physicochemical, nutritional, antioxidant and sensory characteristics of lentil-wheat bread under locally available raw materials and processing conditions remain limited. Moreover, there is inadequate information regarding the optimum incorporation level that maximizes nutritional enhancement without adversely affecting bread quality and consumer acceptability. Such knowledge is essential for commercial bakeries, food processors and public health nutrition programs aiming to develop functional bakery products.

The proposed research therefore seeks to develop nutritionally enriched lentil-wheat composite bread and comprehensively evaluate its proximate composition, mineral profile, antioxidant potential, physical characteristics, texture, sensory quality and overall nutritional value. The findings will contribute to the development of healthier bakery products, encourage the utilization of locally available pulses, support value addition in the food industry and provide scientific evidence for improving dietary quality through functional staple foods. Furthermore, the project aligns with global initiatives promoting sustainable food systems, plant-based protein utilization and the development of functional foods for improved public health.

2. Materials and Methods

2.1 Experimental Site

The study was conducted at The Islamia University of Bahawalpur, Pakistan's Department of Food Science and Technology, Faculty of Agriculture and Environment. The Food Processing Laboratory developed bread, while the Food Chemistry and Food Analysis Laboratories performed physicochemical, nutritional, instrumental, and sensory evaluations.

2.3 Production of raw materials

Table 1. Treatments used in the study

Treatment	Wheat Flour (%)	Lentil Flour (%)
T ₀	100	0
T ₁	95	5
T ₂	90	10
T ₃	85	15
T ₄	80	20

Commercial refined wheat flour, whole lentils (*Lens culinaris*), instant dry yeast, granulated sugar, common salt, and shortening and other baking ingredients were bought from the local market of Bahawalpur, Pakistan. All chemicals and reagents used during laboratory analyses were of analytical grade.

2.3 Preparation of Lentil Flour

All the lentils were hand-sorted to remove broken lentils, dust, etc. After cleaning, the lentils were thoroughly washed with potable water and dried in hot air oven at 50-55°C till a fixed moisture content was reached. Dried lentils were ground with a laboratory grinder and sieved through 60-mesh to get the uniformly sized flour. The flour was placed in sealed PE bags and kept at 4°C until the time of use (Turfani *et al.*, 2017; Marchini *et al.*, 2021).

2.4 Preparation of Composite Flour

Different levels of wheat flour were substituted with lentil flour to prepare composite flour blends. Five formulations were developed as presented in Table 1. All the flour blends were thoroughly mixed with a laboratory mixer to ensure the even distribution of ingredients. The breads were made by straight dough method with some modifications as per AACC International (2010). All the ingredients were weighed as per formulation and mixed thoroughly to get homogeneous dough. Water was added drop by drop to get the optimum consistency of dough. The kneading of the dough was done mechanically until the gluten was properly formed, and the dough was left to ferment for 60 min at 30 ± 2°C. The fermented dough was punched, molded into baking pans and proofed for about 40 min. The dough was baked at 200°C ± 5 in a preheated oven for 25-30 min. The baked loaves were allowed to cool to room temperature for 2 h, wrapped in polyethylene bags and kept at ambient temperature. The instrumental analyses were carried out 24 h after the baking to enable moisture equilibration.

2.6 Physical Properties of Bread

The weight, volume, specific volume, and baking loss of the generated bread samples were used to determine their

physical characteristics. After cooling to room temperature, the weight of the loaf was measured using a calibrated digital analytical balance and reported in grams. The approved AACC International (2010) process was followed while measuring the volume of loaves using the fast seed displacement method. The specific volume (cm³/g) was calculated by dividing the weight of the loaf by its volume. The following formula was used to determine the baking loss (%) for each loaf by comparing the weight of the dough before baking to the weight of the baked bread.

Baking Loss(%)

$$= \frac{(\text{Weight of Dough} - \text{Weight of Bread})}{\text{Weight of Dough}} \times 100$$

2.7 Instrumental Quality Evaluation

2.7.1 Texture Profile Analysis

A TA was used to perform a texture profile analysis (TPA) of the bread samples. TA.XT Plus Texture Analyzer with cylindrical compression probe (Stable Micro Systems, Surrey, UK). Bread slices with a constant thickness of 25 mm that had been reduced to 40% of their initial thickness were subjected to a double compression test. The instrument's pre-test, test, and post-test speeds were 1.0 mm/s, 1.0 mm/s, and 5.0 mm/s, respectively. The conventional texture profile analysis method described by Bourne (2002) was used to measure hardness, springiness, cohesion, gumminess, chewiness, and resilience.

2.7.2 Color Measurement

A TA was used to perform texture profile analysis (TPA) on the bread samples with Texture Analyzer's cylindrical compression probe (Stable Micro Systems, Surrey, UK). Bread slices with a constant thickness of 25 mm that were reduced to 40% of their initial thickness were subjected to a double compression test. The instrument's pre-test, test, and post-test speeds were, respectively, 1.0 mm/s, 1.0 mm/s, and 5.0 mm/s. The standard texture profile analysis method described by Bourne (2002) was used to measure hardness, springiness, cohesiveness, gumminess, chewiness, and resilience.

2.7.3 Water Activity

A water activity meter with an internal calibration was used to measure the water activity (aw) at 25 ± 2 °C, and representative crumb samples were placed in the water activity sample cup and equilibrated in the water activity measuring chamber before the water activity measurements were made. Standard analytical procedures outlined by

Table 2. Proximate composition of lentil-wheat composite breads

Parameters	T ₀	T ₁	T ₂	T ₃	T ₄
Moisture	33.80±1.5e	34.00±1.1d	34.20±1.2c	34.50±1.7b	34.80±1.9a
Protein	10.60±0.5e	11.25±0.7d	11.95±0.2c	12.70±0.4b	13.45±0.8a
Fat	2.30±0.03e	2.35±0.05d	2.42±0.04c	2.48±0.05b	2.55±0.03a
Ash	1.15±0.03d	1.28±0.03c	1.42±0.09b	1.56±0.01b	1.72±0.05a
Crude Fiber	1.05±0.03e	1.42±0.05d	1.82±0.04c	2.25±0.03b	2.70±0.04a
Carbohydrates	51.10±3.9a	49.70±6.1b	48.19±6.3c	46.51±2.1d	44.78±6.2e

T₀ = 100% wheat flour (control); T₁ = 95% wheat flour + 5% lentil flour; T₂ = 90% wheat flour + 10% lentil flour; T₃ = 85% wheat flour + 15% lentil flour; T₄ = 80% wheat flour + 20% lentil flour.

AOAC International (2019) were followed during the determination of water activity.

2.8 Nutritional Evaluation

2.8.1 Proximate Composition

Supplemented flours breads were analyzed for moisture, crude protein, crude fat, crude fiber, total ash and carbohydrates by following the standard procedures outlined by AACC (2019).

2.8.2 Gross Energy

Automatic Bomb Calorimeter was used to determine Gross energy. The dried and finely ground samples of bread were pelletized and then burned under pressure of oxygen and the calorific value was calculated based on 100 g bread.

2.8.3 Mineral Analysis

The contents of iron (Fe), zinc (Zn) and calcium (Ca) were determined by Atomic Absorption Spectrophotometry (AAS) after wet acid digestion as per the standard methods of AOAC International (2019).

2.9 Sensory Evaluation

Sensory review was carried out by a panel of thirty trained panelist, including faculty and post-graduation students. A glass of drinking water was provided to rinse the mouth in between each of the tagged bread samples, which were distributed in a random order. A nine-point hedonic scale was used to assess the appearance, crust color, crumb color, scent, taste, texture, and overall acceptability (Meilgaard *et al.*, 2007).

2.10 Statistical Analysis

IBM SPSS Statistics (Version 26.0) was used to do a one-way analysis of variance (ANOVA) on the data. Tukey's HSD test was used to perform mean separation at a 5% significance level. The findings are displayed as mean ± standard deviation (n = 3) (Steel *et al.*, 1997).

3. Results and Discussion

3.1 Proximate Composition

Table 2 shows the created lentil-wheat composite bread's approximate composition. The bread's nutritional makeup was dramatically ($p < 0.05$) changed when lentil flour was partially substituted for wheat flour. Moisture content increased gradually, from 33.80% in the control (T₀) to 34.80% in T₄. As the amount of lentil flour grew, the protein content also steadily rose from 10.60% to 13.45%. Ash (1.15-1.72%), crude fiber (1.05-2.70%), and fat (2.30-2.55%) all showed similar rising trends. The carbohydrate level of bread made with 20% lentil flour, on the other hand, steadily dropped from 51.10% in control treatment to 44.78%.

The compositional variations between wheat and lentil flour are responsible for these alterations. Because lentil flour has more protein, dietary fiber, and minerals than refined wheat flour, the composite bread's nutritional profile was enhanced. While the decrease in carbohydrate content was caused by the partial substitution of lentil flour for starch-rich wheat flour, its better water absorption capacity also encouraged slightly increased moisture retention. Turfani *et al.* (2017) and Marchini *et al.* (2021) have observed similar improvements in protein, ash, crude fiber, and moisture content along with a decrease in carbs for lentil-enriched wheat bread. Additionally, Boye *et al.* (2010) showed that adding pulse flours successfully raises the protein content of cereal-based baked goods.

3.2 Mineral Composition

Figure 1 illustrates the mineral makeup of lentil-wheat composite bread. The concentration of every mineral that was examined increased significantly ($p < 0.05$) when lentil flour was added. Zinc concentration rose from 0.82 to 1.18 mg/100 g, whereas iron content rose from 1.45 mg/100 g in the control bread (T₀) to 2.75 mg/100 g in T₄. Calcium showed a similar trend, rising from 20 mg/100 g in the control treatment to 34 mg/100 g after 20% lentil flour was substituted. These findings show that adding more lentil flour successfully improves the composite bread's mineral profile.

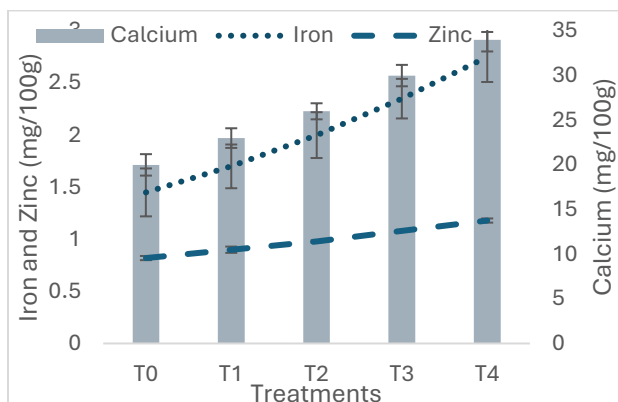


Figure 1. Minerals composition of the lentil-wheat based composite bread

The naturally higher amounts of iron, zinc, calcium, and other important minerals found in lentil flour as opposed to refined wheat flour are the main cause of the improvement in mineral content. As a result, substituting some of the wheat flour with lentil flour enhanced the bread's nutritional value and added valuable micronutrients. Turfani *et al.* (2017) reported similar improvements in mineral content, finding that supplementing wheat bread with lentil flour improved its ash and mineral composition. Boye *et al.* (2010) emphasized pulses as useful fortifying ingredients for boosting the micronutrient content of cereal-based baked goods, whereas Marchini *et al.* (2021) showed enhanced nutritional quality with increasing quantities of red lentil flour.

3.3 Gross Energy and Water Activity

Table 3 shows the produced composite bread's gross energy and water activity. Both characteristics were considerably ($p < 0.05$) impacted by increasing the percentage of lentil flour. From 267 kcal/100 g in the control group (T_0) to 282 kcal/100 g in T_4 , gross energy gradually increased. On the other hand, when the proportion of lentil flour increased, water activity dropped somewhat from 0.952 to 0.942, suggesting that there was less free water in the bread.

The higher protein and lipid contents of lentil flour relative to refined wheat flour are the primary cause of the composite

Table 3. Gross energy and water activity of the lentil-wheat composite bread

Treatment	Gross Energy (kcal/100 g)	Water Activity
T ₀	267±12.2d	0.952±0.03
T ₁	270±14.1cd	0.950±0.02
T ₂	274±16.3bc	0.948±0.01
T ₃	278±18.1ab	0.945±0.04
T ₄	282±11.5a	0.942±0.07

T_0 = 100% wheat flour (control); T_1 = 95% wheat flour + 5% lentil flour; T_2 = 90% wheat flour + 10% lentil flour; T_3 = 85% wheat flour + 15% lentil flour; T_4 = 80% wheat flour + 20% lentil flour.

bread's higher gross energy values. However, the increased water-binding capacity of lentil proteins and dietary fiber, which hold water within the bread structure and decrease its availability, may account for the decrease in water activity. Improved microbiological stability during storage could be a result of this decrease in water activity. Boye *et al.* (2010) noted pulses as useful components for raising the nutrient density of cereal-based goods, whereas Turfani *et al.* (2017) showed similar gains in the nutritional quality of pulse-fortified bread. Mohammed *et al.* (2012) similarly noted a similar drop-in water activity after adding legume flour, attributing this impact to the potent hydration qualities of legume fiber and proteins.

3.4 Physical Properties

Table 4 summarizes the physical attributes of lentil-wheat composite bread. There were significant ($p < 0.05$) variations between the treatments. As the amount of lentil flour rose, the loaf volume decreased from 1850 cm³ to 1650 cm³, but the loaf weight increased from 448 g in the control (T_0) to 460 g in T_4 . There was also a comparable decrease in specific volume, which dropped from 4.13 cm³/g in the control to 3.59 cm³/g in T_4 . In contrast, baking loss dropped from 12.8% to 11.4% as the substitute amount increased.

The higher water absorption and moisture retention ability of lentil flour, which decreased moisture evaporation during

Table 4. Physical Properties of the lentil-wheat composite bread

Parameters	T ₀	T ₁	T ₂	T ₃	T ₄
Loaf Weight (g)	448±1.1e	450±1.4d	453±1.2c	456±1.9b	460±1.7a
Loaf Volume (cm ³)	1850±1.3a	1820±1.4b	1775±1.2c	1715±1.8d	1650±1.4e
Specific Volume (cm ³ /g)	4.13±0.4a	4.04±0.1b	3.92±0.6c	3.76±0.3d	3.59±0.5e
Baking Loss (%)	12.8±0.9a	12.4±0.8b	12.1±0.7c	11.8±0.8d	11.4±0.6e

T_0 = 100% wheat flour (control); T_1 = 95% wheat flour + 5% lentil flour; T_2 = 90% wheat flour + 10% lentil flour; T_3 = 85% wheat flour + 15% lentil flour; T_4 = 80% wheat flour + 20% lentil flour.

Table 5. Texture Profile Analysis of the lentil-wheat composite bread

Parameters	T ₀	T ₁	T ₂	T ₃	T ₄
Hardness (N)	5.2±0.5e	5.8±0.3d	6.6±0.2c	7.5±0.5b	8.7±0.2a
Springiness	0.91±0.04a	0.90±0.06ab	0.88±0.03b	0.86±0.04c	0.84±0.03d
Cohesiveness	0.67±0.09a	0.66±0.03b	0.65±0.01c	0.63±0.06d	0.61±0.07e
Gumminess	3.48±0.1e	3.83±0.3d	4.29±0.2c	4.73±0.1b	5.31±0.2a
Chewiness	3.17±0.3e	3.44±0.5d	3.78±0.4c	4.07±0.3b	4.46±0.5a
Resilience	0.42±0.02a	0.41±0.03ab	0.40±0.06bc	0.38±0.03b	0.36±0.02c

Table 6. Color analysis of crust and crumb of the lentil-wheat composite bread

Treatment	Crust			Crumb		
	L*	a*	b*	L*	a*	b*
T ₀	58.5±0.03a	9.2±0.05e	24.8±0.03e	74.5±0.01a	1.25±0.02d	18.4±0.03e
T ₁	57.0±0.04b	9.8±0.03d	25.4±0.06d	72.8±0.07ab	1.55±0.04cd	19.2±0.04d
T ₂	55.5±0.03c	10.4±0.09c	26.2±0.07c	71.0±0.03b	1.90±0.02c	20.0±0.05c
T ₃	54.2±0.02d	11.1±0.05b	27.0±0.03b	69.2±0.01c	2.25±0.06ab	21.1±0.06b
T ₄	52.6±0.01e	11.9±0.03a	28.0±0.04a	67.0±0.02d	2.70±0.03a	22.3±0.01a

T₀ = 100% wheat flour (control); T₁ = 95% wheat flour + 5% lentil flour; T₂ = 90% wheat flour + 10% lentil flour; T₃ = 85% wheat flour + 15% lentil flour; T₄ = 80% wheat flour + 20% lentil flour.

baking, may account for the rise in loaf weight and the decreased baking loss. Nevertheless, the gluten network was decreased when gluten-free lentil flour was substituted for wheat flour, which limited gas retention and bread expansion during fermentation and baking. Consequently, breads made with more lentil flour showed reduced specific volume and loaf volume. Turfani *et al.* (2017) reported similar results, indicating that lentil-enriched wheat bread had higher loaf weight but lower loaf volume. Similar alterations in the physical characteristics of legume-based composite breads were observed by Mohammed *et al.* (2012), while Marchini *et al.* (2021) linked decreased loaf expansion with gluten dilution after using red lentil flour.

3.5 Texture Profile Analysis

Table 5 displays the texture profile attributes of the lentil-wheat composite bread. There were notable ($p < 0.05$) differences between the treatments. Gumminess (3.48-5.31) and chewiness (3.17-4.46) both increased when hardness rose from 5.2 N in the control (T₀) to 8.7 N in T₄. On the other hand, as the amount of lentil flour increased, springiness, cohesiveness, and resilience progressively decreased from 0.91 to 0.84, 0.67 to 0.61, and 0.42 to 0.36, respectively. The gradual substitution of gluten-free lentil flour for wheat flour is the main cause of the textural alterations that have been noticed. A denser, firmer crumb structure was created by diluting the gluten network, which decreased the dough's elasticity and gas retention. Furthermore, lentil flour's higher

protein and dietary fiber content encouraged water absorption and made the crumb more compact, which increased the crumb's hardness, gumminess, and chewiness. The concomitant decrease in cohesion, robustness, and springiness was indicative of the bread matrix's decreased elasticity. Marchini *et al.* (2021) showed similar patterns, noting that bread made with red lentil flour had less elasticity and more hardness. Mohammed *et al.* (2012) reported similar changes in the texture of legume-fortified composite breads, whereas Turfani *et al.* (2017) reported harder bread with less springiness as lentil flour substitution increased.

3.6 Color Analysis

Table 6 displays the color values of the lentil-wheat composite bread's crust and crumb. There were significant ($p < 0.05$) variations between the treatments. The L* values of the crust and crumb dropped as the percentage of lentil flour rose; the crust's lightness fell from 58.5 to 52.6 and the crumb's from 74.5 to 67.0, suggesting the creation of a darker product. On the other hand, the values of a* (redness) and b* (yellowness) gradually rose in both the crust and the crumb. While crumb a* climbed from 1.25 to 2.70 and b* from 18.4 to 22.3, crust a* and b* values increased from 9.2 to 11.9 and 24.8 to 28.0, respectively.

The inherent pigments in lentil flour and improved Maillard browning during baking are probably responsible for the composite bread's darker appearance. Additional amino groups that take part in browning reactions are provided by

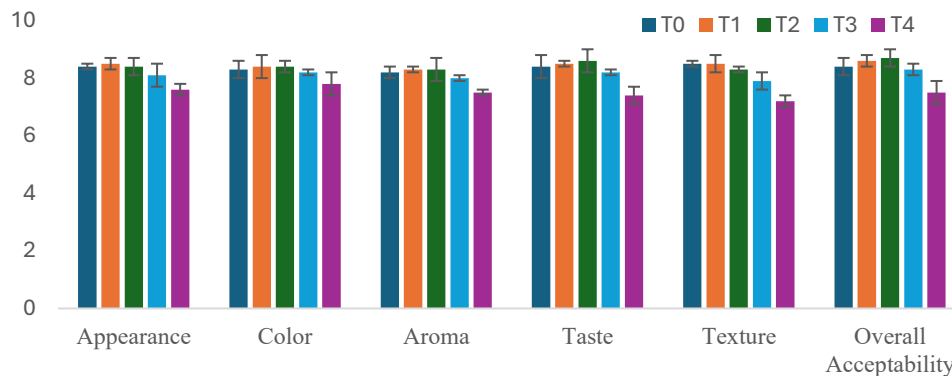


Figure 2. Sensory scores of the lentil-wheat based composite bread

the increased protein content of lentils, and the natural color of lentil flour also helps to lessen lightness. Turfani *et al.* (2017) showed similar alterations in color characteristics, finding that lentil-enriched wheat bread had higher a^* and b^* values and lower L^* values. While Mohammed *et al.* (2012) linked similar color changes in breads enriched with legumes to enhanced Maillard reactions and the natural pigments found in pulse flours, Marchini *et al.* (2021) similarly documented greater browning intensity with red lentil flour incorporation.

3.7 Sensory Evaluation

Figure 2 displays the findings of the lentil-wheat composite bread's sensory evaluation. The treatments differed significantly ($p < 0.05$) in terms of appearance, color, taste, texture, scent, and overall acceptance. The bread with 5% and 10% lentil flour (T_1 and T_2) was rated as the most acceptable overall, with T_2 receiving the highest sensory scores. Sensory scores gradually decreased as lentil flour substitution increased (15-20%), and T_4 received the lowest ratings for all assessed characteristics. All formulations, however, were deemed satisfactory, with scores staying above the 9-point hedonic scale's midpoint.

The positive reception of bread made with 10% lentil flour suggests that moderate supplementation enhanced nutritional quality without sacrificing appealing sensory qualities. The harder crumb, darker color, and distinctive beany flavor supplied by lentil flour were probably responsible for the poorer ratings seen at greater substitution levels. The panelists' opinions of texture and general palatability might have been impacted by these characteristics. Similar findings were published by Turfani *et al.* (2017), who discovered that while excessive substitution negatively impacted sensory quality, moderate amounts of lentil flour provided bread with

the highest consumer acceptability. According to Marchini *et al.* (2021), bread with up to 10–15% red lentil flour still had outstanding sensory qualities, while bread with higher inclusion levels was less palatable due to its darker color and firmer texture. Additionally, Mohammed *et al.* (2012) found that adding bean flours to bread in moderation enhanced its nutritious value without sacrificing customer satisfaction.

4. Conclusion

Partial substitution of wheat flour with lentil flour significantly improved the nutritional quality of composite bread by increasing protein, crude fiber, mineral content, and gross energy while reducing carbohydrate content. Although higher levels of lentil flour decreased loaf volume, specific volume, lightness, and textural elasticity, these changes were accompanied by improved nutritional attributes. Sensory evaluation indicated that bread containing 10% lentil flour (T_2) achieved the highest overall acceptability, whereas further substitution slightly reduced consumer preference. Overall, the results suggest that 10% lentil flour substitution is the optimum level for producing nutritionally enriched bread with desirable physicochemical, textural, and sensory characteristics. The study demonstrates that lentil flour is a promising functional ingredient for developing healthier bakery products and offers a practical approach to enhancing the nutritional value of wheat bread.

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Conflict of Interest

The authors declare no conflict of interest.

Authors' Contribution

The project was conceptualized by Umair Ali, who also carried out experimental work and collected data. Sana Somro, oversaw the research, helped with the study design and methodology, verified the findings, critically examined and rewrote the article. Hammad Hafeez helped with data curation, literature review, laboratory analysis, document editing, and visualization.

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