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# Nutritional and Quality Attributes of Wheat Bread Fortified with Different Levels of Dehulled Extruded Faba Bean (*Vicia Faba* L.) Powder

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***Abstract***

***Background:*** *Malnutrition is a major public health issue in developing regions.*
***Purpose:*** *The current study was designed to assess the effect of addition various levels of dehulled - extruded faba bean powder (DEFB) on the nutritional and quality aspects of wheat bread.*
***Design/methodology/approach:*** *Different ratios of DEFB powder (0 %- 8 %) were incorporated into wheat flour to prepare composite bread. Chemical composition, mineral content, zas well as amino acids profile of DEFB powder and wheat flour were investigated. The samples of enriched breads were evaluated for proximate composition, mineral nutrients, amino acid composition, physical qualities, and sensory aspects.*
***Findings:*** *Protein and ash contents of DEFB powder were shown to be 2.90 and 6.73 times greater than wheat flour. DEFB powder contains higher quantities of calcium (230 mg/100 g), phosphorus (136.06 mg/100 g), magnesium (198.00 mg/100 g), potassium (1325.00 mg/100 g), and sodium (80.94 mg/100 g). DEFB powder protein is rich in essential amino acids, such as isoleucine, leucine, lysine, total aromatic amino acids, threonine, and valine Bread sample enriched with 8 % DEFB powder had the highest (12.94%) protein content, on the contrary the un-fortified bread had the lowest (11.58%) protein. The incorporation of DEFB powder at 8 % caused significant decrease($P \leq 0{:}05$) in carbohydrate content compared to the control sample without addition. Mineral nutrient contents were higher in the bread samples containing DEFB powder than control samples. Control samples and bread samples enriched with 2 and 4 % DEFB powder had the highest specific volumes. Lysine is still the limiting amino acid in the experimental bread samples, however fortification of wheat flour with DEFB powder reduced the lysine deficiency. Control sample and bread samples enriched with 2% and 4% DEFB powder received the highest scores of overall acceptability, whereas the bread sample with the highest DEFB powder (8 %) received the lowest scores.*
***Practical implications:*** *The current study's major findings suggested that incorporation of 2-4 % EDFB powder into wheat flour improved the nutritional and qualitative aspects of wheat bread.*

***Keywords:*** *Faba bean, bread, wheat, functional food, protein, and organoleptic.*

## Introduction

Wheat bread is a popular food worldwide. It is a source of complex carbohydrates and calories [1]. However, wheat bread is considered to be of low nutritional quality because it has low concentrations of micro- and macro nutrients [2]. The enrichment of wheat flour with legume flours is an applicable method to improve the nutritional quality of cereal-based foods. Legumes exhibit complementary amino acid profiles to those of cereal-based foods diets [3,4], and they are also rich in bioactive compounds such as fibers and phytochemicals [5].

Among legumes, faba bean (Vicia faba L.), also known as fava bean, broad bean, and horse bean, is one of the oldest crops cultivated worldwide [6]. Faba bean seeds are rich in protein, carbohydrates, fiber and vitamins and have a hypocholesterolemic effect [7]. Faba bean seeds are an important source of proteins and also contains starch, fiber, choline, lecithin, vitamins, and minerals [8]. The protein content of faba beans ranges from 20% to 41%, depending on the variety. Faba bean seeds contain 51% to 68% carbohydrate in total, the major portion of which is starch (41% to 53%) [9]. Faba beans are a good source of valuable mineral micronutrients such as phosphorus, potassium, calcium, sulfur, and iron. [10]. However, their nutritional value is affected by the presence of antinutritional factors such as trypsin inhibitors, condensed tannins, phytic acid, saponins, lectins, and favism-inducing factors [11]. Removal of these antinutrients is therefore necessary for effective utilization of food legumes in human nutrition. There are different traditional and technological processing ways, which can be used to reduce the levels of these anti-nutrient factors by heat processing (boiling, cooking, autoclaving or extrusion cooking) or eliminated by pretreatments such as dehulling, soaking, germination, fermentation, and supplementation with various chemical and enzymes [11].

Extrusion is one of the most popular practical techniques in the food industry [12] to produce different food products [13] starting from various types of protein enriched ingredients or mixtures. The extrusion process is a highly efficient continuous process in which a few unit processes such as mixing, shearing, heating, pumping, shaping, and sizing combine to produce distinct products [14]. Extrusion processing of legume seeds has been used to remove the antinutritional factors and enhance the physicochemical properties. Extrusion of faba beans has been reported to have minimal effect on the nutritional value, such as protein, lipids, and ash contents [15].

The current investigation aimed to evaluate the impact of the addition of different level of dehulled extruded faba bean powder on the nutritional and quality attributes of wheat bread.

## Materials and methods Materials

### Raw material and chemicals

Dehulled Faba bean (Vicia Faba L.) were obtained from the local market in Buraydah, Qassim, Saudi Arabia. Wheat flour (WF) (all-purpose flour, extraction rate ≈ 72%), was obtained from First milling company, Qassim, Saudi Arabia. Victoria Instant Yeast (Saccharomyces cerevisiae) was manufactured in france by S.I.L-59703 Marcq, France. Bread improver was obtained from Backaldrin Arab Jordon LTD., ALKASTAL, JORDAN). Sunflower was obtained from Afia international Co., Jeddah, KSA. White crystal sugar, salt (Sodium Chloride, NaCl), and full cream milk powder were purchased from the local market in Buraydah, Qassim, Saudi Arabia.

### Preparation dehulled extruded Faba bean (DEFB) powder

The Dehulled Faba bean seeds have been carefully cleaned and separated from the husks and foreign materials . The dehulled Faba bean were crushed and then extruded, the extrusion process was performed with the friendly help of Nova Factory for food industries, Ha'il Industrial City, using a single-screw extruder (Model LG 90, UK) (Murgueytio and Santacruz 2020) [16], the operating parameters that were used after conducting initial experiments. Extruder at 150 rpm, feed rate 15g/min, moisture content 18%, The temperatures in the precondition area reached 80 °C, in the second extrude 100 °C, and in the third dryer area 120 °C, the product was collected and stored in polyethylene bags until use.

### Bread Making Process

The bread baking process was by the direct dough method [17]. The ingredients for bread-making were formulated as described in Table 1. Sugar, full cream milk powder, and salt were first dissolved in a suitable amount of water. Wheat flour, instant active dry yeast, and bread improver were added to the dissolved materials and combined for 4 minutes on low speed, followed by 6 minutes on high speed, in a Kenwood kitchen machine, OWKHC29B0SI, 69036 (Kenwood Co., China). A farinograph (Brabender, Duisburg, Germany) was used to calculate the appropriate quantity of water at a consistency of 500 BU. The oil was added in modest quantities throughout the kneading phase. The finished dough was covered with a clean Muslin towel and left at room temperature for 5 minutes. Following this rest period, the dough was scaled into 80 g pieces, shaped, mechanically moulded, placed into baking forms, and proofed for 60 minutes at 38 °C, 85 % relative humidity (RH). After proofing, the fermented dough pieces were baked for 10 minutes in a rotary oven (CM HS108, Chanmag Bakery Machine Co. Ltd., Taiwan) at 220°C. Baked loaves were kept in a cold room at 20 °C for 2 hours before sensory, physical, and chemical evaluations.

**Table 1:** The Bread Formulas.

| Ingredient | DEFB8% | DEFB6% | DEFB4% | DEFB2% | DEFB0 | DEFB10% |
|---|---|---|---|---|---|---|
| Wheat flour (g) | 1000 | 980 gm | 960 gm | 940 gm | 920 gm | 900 gm |
| DEFB | 0 | 20 gm | 40 gm | 60 gm | 80 gm | 100 gm |
| Yeast | 11 gm | 11 gm | 11 gm | 11 gm | 11 gm | 11 gm |
| sugar(g) | 50 gm | 50 gm | 50 gm | 50 gm | 50 gm | 50 gm |
| Salt (g) | 10 gm | 10 gm | 10 gm | 10 gm | 10 gm | 10 gm |
| Bread Improver (g) | 3 gm | 3 gm | 3 gm | 3 gm | 3 gm | 3 gm |
| Refined Sunflower oil (ml) | 30 gm | 30 gm | 30 gm | 30 gm | 30 gm | 30 gm |
| full cream milk powder (g) | 7 gm | 7 gm | 7 gm | 7 gm | 7 gm | 7 gm |
| Water (mL) | 61.1 gm | 61.6 gm | 61.9gm | 62.5gm | 62.6gm | 62.7gm |

### Evaluation of the nutritional attributes

Wheat flour, extruded-dehulled faba bean as well as bread samples were analyzed for physico-chemical properties Moisture, crude ash, crude proteins, crude fiber and crude fat were assessed according to AOAC (2000) [18]. Total Carbohydrate content was determined by estimated by subtracting the sum of the ash, proteins, crude fiber and fat contents from 100% [3], Energy value (kcal/100 g) was calculated using the following equation (according to Ali et al. (2020) [2]. Energy (kcal/100 g) = [(9 x lipids%) + (4 x proteins%) +(2 x fiber%) + (4 x carbohydrates %)].

Mineral composition [Iron (Fe), zinc (Zn), copper (Cu), calcium (Ca), magnesium (Mg) Iron (Fe), zinc (Zn), copper (Cu), calcium (Ca) and magnesium (Mg)] were determined by atomic absorption spectrometer procedures described by Althwab et al. (2021) [19].

Amino acids were assayed by an automatic amino acid analyzerAAA400 (INGOS, Czech Republic) according to the standard procedures of Coda et al. (2017) [20].

### Physical properties of bread samples

The specific volume was then calculated by the volume of the bread divided by its weight in accordance with the method AACC No. 10-05.01 (2000) [18].

### Sensory Evaluation (Acceptance and preference Testing)

Composite bread samples (0% DEFB, 2% DEFB, 4 % DEFB, 6 % DEFB, 8 % DEFB. 10% DEFB) and control bread sample were subjected to sensory assessment for determination of consumer acceptance and preference. Sensory analysis was performed by a panel of 15 judges from the staff of Department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, Buraydah, Saudi Arabia to evaluate the organoleptic properties of formulated bread samples. The panelists were instructed to evaluate the quality attributes of the bread samples: texture, aroma, taste, color and overall acceptability on a nine-point Hedonic scale where 9 = Like extremely and 1 = Dislike extremely [3].

### Statistical Analysis

All data were subjected to analysis using SPSS (version 20). The results were statistically analyzed in triplicate except for the sensory evaluation results (n=15). One-way analysis of variance (ANOVA) was carried out at a 5 % significance level to differentiate among treatments and means were compared by Duncan's multiple range test.

## Results and Discussion

### Proximate composition and mineral content of dehulled- extruded faba bean powder and wheat flour

The results of proximate composition and mineral content of dehulled- extruded faba bean (DEFB) powder and wheat flour are presented in Table 2. DEFB powder contained a protein content of 32.50 g/100 g on a dry basis, which is 2.90 times higher than wheat flour. The protein content of faba beans ranges from 20% to 41%, depending on the variety [9,21]. The protein content of the dried fava beans ranged from 26 to 33 % on a dry weight basis [22]. DEFB powder had higher ash content (3.50 %) than that of wheat flour (0.52 %). According to these findings, it was found that DEFB powder can serve as à source of protein and minerals. Faba bean (Vicia faba L.) is a significant source of pro¬teins and also contains starch, fiber, bioactive compounds, lecithin, vitamins, and minerals [21]. These results are similar to those obtained by Labba et al. 2021 [22] who reported that ash content in fifteen fava bean varieties cultivated in Sweden ranged from 2.83 to 3.41 %. The result of the current study indicated also that wheat flour predominantly contains high amount of carbohydrate (86.40 %) followed by protein (11.19%). The mineral content wheat flour and DEFB powder is presented in Table 2. Generally, DEFB powder typically contains high concentrations of minerals compared to wheat flour that make it a very attractive for fortification process. Higher levels of calcium (230 mg/100 g), phosphorus (136.06 mg/100 g), magnesium (198.00 mg/100 g), potassium (1325.00 mg/100 g) and sodium (80.94 mg/100 g) were noted in DEFB powder. Faba bean contains a variety of minerals (sodium, potassium, calcium, copper, zinc, iron, manganese, magnesium, phosphorus, and sulfur) [15,23]. These findings showed that DEFB powder can effectively be utilized as a rich source of protein, carbohydrates and minerals.

**Table 2:** Chemical Composition (g per100 g dry weight basis) and minerals content(mg/100g) of wheat flour, Dehulled-extruded Faba bean (DEFB) powder.

| Components | Wheat flour | Dehulled -extruded Faba bean (DEFB) |
|---|---|---|
| Moisture | 12.60 | 8.56 |
| Crude protein | 11.19 | 32.50 |
| Fat content | 1.07 | 1.30 |
| Dietary fibers | 1.18 | 1.10 |
| Ash | 0.52 | 3.50 |
| Total carbohydrates | 86.40 | 61.60 |
| Energy value (kCal/100 g) | | |
| Ca | 24.85 | 230 |
| P | 389 | 136.06 |
| Mg | 10.35 | 198 |
| Na | 10.65 | 80.94 |
| K | 6.41 | 1325 |
| Cu | 0 | 19.45 |
| Fe | 8.23 | 9.85 |
| Zn | 3.1 | 5 |
| Mn | 0.87 | 0.20 |

Values are means ± SD of three replicates.
Means in the same row with different letters are significantly different ($p \leq 0.05$).
ND means not detected.

**Amino acids composition of wheat flour, Dehulled-extruded Faba bean (DEFB) powder (g/100 g protein)**

The nutritional quality of a protein is principally governed by its amino acid composition. Amino acid compositions of wheat flour, Dehulled- extruded Faba bean (DEFB) powder. (g/100 g protein) are presented in Table 3. Essential amino acids represented 33.18% of the total amino acid content of wheat flour protein. Wheat flour protein was rich in isoleucine, leucine, cystine, Methionine as well as total aromatic amino acids compared with the FAO/WHO/ UNU, 2007 (1–2 yrs.) reference values. Lysine and threonine were slightly deficient in wheat flour protein. Essential amino acids formed 37.22% of the total amino acid content of dehulled- extruded faba bean (DEFB) powder protein. DEFB powder protein is rich in essential amino acids, such as isoleucine, leucine, lysine, total aromatic amino acids, threonine, and valine, with values comparing favorably with the FAO/WHO/ UNU, 2007 (1-2 yrs.) reference values. Therefore, Dehulled- extruded Faba bean (DEFB) powder protein could very well complement those protein sources that are low in lysine such as wheat flour proteins. Nonessential amino acids represented 62.78% of the total amino acid content. Arginine, aspartic acid, and glutamic acid were the major nonessential amino acids in dehulled-extruded faba bean (DEFB) powder protein, with contents of 8.06%, 11.50 %, and 18.30%, respectively sub-optimal, being limited by the levels of the essential sulfur amino acids as well as tryptophan, and generally contain high levels of leucine, lysine, aspartic acid, arginine and glutamic acid (Boye et al., 2010). In contrast, most cereal grains contain a low level of lysine but very high levels of sulfur-containing amino acids, which is the reason why these two food categories are considered as complementary in a plant-based diet [22].

**Table 3:** Amino acids composition of wheat flour, Dehulled- extruded Faba bean (DEFB) powder (g/100 g protein).

| **Amino acid** | **Wheat flour** | **Dehulled -extruded Faba bean (DEFB)** | **FAO/WHO/UNU, 2007 (1-2 yrs.)** |
|---|---|---|---|
| Isoleucine | 3.79 | 5.17 | 3.1 |
| Leucine | 9.15 | 8 | 6.3 |
| Lysine | 1.59 | 6.11 | 5.2 |
| Cystine | 4.35 | 0.8 | |
| Methionine | 1.89 | 0.7 | |
| **Total sulfur amino acids** | 6.24 | 1.5 | 2.6 |
| Tyrosine | 3.3 | 2.4 | |
| Phenylalanine | 5.15 | 4.1 | |
| **Total aromatic amino acids** | 8.45 | 6.5 | 4.6 |
| Threonine | 1.66 | 4.7 | 2.7 |
| Valine | 2.3 | 5.24 | 4.2 |
| **Total essential amino acid** | 33.18 | 37.22 | |
| Histidine | 1.58 | 2.55 | 1.8 |
| Arginine | 2.27 | 8.06 | |
| Aspartic acid | 6.79 | 11.5 | |
| Glutamic acid | 34.97 | 18.3 | |
| Serine | 4.31 | 6.1 | |
| Proline | 6.65 | 6.1 | |
| Glycine | 4.31 | 5.1 | |
| Alanine | 5.93 | 5.07 | |
| Total non-essential amino acids | 66.81 | 62.78 | |
| Chemical score (CS) (%) | Lysine( 30.58) | | |
| First limiting amino acid | 30.5769 | | |
| P-PER | 3.3396 | 2.912 | |
| Values are means ± SD of three replicates.<br>Means in the same row with different letters are significantly different (p ≤ 0.05).<br>ND means not detected. | | | |

**Chemical Composition (g per100 g dry weight basis), minerals content(mg/100g) and physical characteristics of bread fortified with various amounts of Dehulled- extruded Faba bean (DEFB)**

The chemical Composition (g per100 g dry weight basis) and minerals content(mg/100g) and physical characteristics of bread fortified with various amounts of dehulled- extruded faba bean (DEFB) are presented in Table 4. Moisture content of composite bread sample ranged from 36.89 to 40.08. Bread samples supplemented with different levels of DEFB powder had higher amounts of moisture content than control bread without addition. Bread samples containing 8% DEFB powder had the highest moisture content (40.08%). This finding may be attributed to the ability of DEFB powder to absorb and retain more of water than wheat flour (Farinograph results). A higher protein content in DEFB powder could explain the higher absorption ability (Table 2). Proteien content of bread samples ranged from 11.58 to 12.94 %. Bread sample supplemented with 8 % DEFB powder had the highest (12.94%) protein conten, on the contrary the un-fortified bread had the least (11.58%) protein. Protein content of bread samples significantly (P≤0:05) increased with increasing DEFB powder substitution (Table 4). The protein content of faba beans ranges from 24% to 35% of the seed dry matter [10], making it the most protein-rich main pulse crop [24]. There were no statistically significant changes in fat and fiber contents between the fortified and unfortified bread samples (P≥0:05). The ash content of bread samples ranged from 1.35 to 1.58 g/100 g and increased with progressive increase in the proportion of DEFB powder in the composite flours. Bread samples supplemented with 8 % DEFB powder had the highest content of ash (1.58%), however the lowest content (1.35 %) was recorded from the unfortified samples (100% wheat flour). In fact, the incorporation of DEFB powder at 8 % caused a statistically significant decrease(P≤0:05) in carbohydrate content compared to the control sample without addition. The carbohydrate contents of the fortified bread samples decreased significantly (P < 0.05) as DEFB powder level was increased. The highest carbohydrate contents (83.64 and 83.08 %) were observed in the bread samples prepared from the 100% wheat flour (control samples) and and bread samples fortified with 2% DEFB powder whereas the lowest (81.89 %) was observed in the breads prepared from highest substitution (8%) of the DEFB powder. Mineral nutrient contents were higher in the bread samples containing DEFB powder than control samples without DEFB powder addition; bread samples with 8 % fortification level had highest values of 62.9, 330.74, 33.80 and 170.1, mg/100 g for respective Ca, P, Mg, and K, respectively while lowest values were recorded for the control (unfortified bread sample). There were no statistically significant (P≥0:05) differences in Na, Fe, Zn and Mn content were observed between fortified and unfortified bread samples. Legumes are a rich source of many micronutrients that are typically deficient in human diets. Legume seeds generally have higher levels of minerals (e.g., Fe, Zn, Ca, and Mg) than cereal [24,25].

**Table 4:** Chemical Composition (g per100 g dry weight basis) and minerals content(mg/100g) and physical characteristics of bread fortified with various amounts of Dehulled- extruded Faba bean (DEFB).

| Components | Samples | | | | |
|---|---|---|---|---|---|
| | DEFB0 | DEFB2% | DEFB4% | DEFB6% | DEFB8% |
| Moisture | 36.89 | 37.51 | 38.66 | 39.30 | 40.08 |
| Crude protein | 11.58 | 12.04 | 12.47 | 12.90 | 12.94 |
| Fat content | 2.56 | 2.59 | 2.63 | 2.71 | 2.77 |
| Dietary fibers | 0.87 | 0.87 | 0.85 | 0.84 | 0.82 |
| Ash | 1.35 | 1.42 | 1.50 | 1.54 | 1.58 |
| Total carbohydrates | 83.64 | 83.08 | 82.55 | 82.01 | 81.89 |
| Energy value (kCal/100 g) | | | | | |
| **Mineral analysis (mg/100g)** | | | | | |
| Ca | 49.35 | 53.85 | 58.85 | 58.40 | 62.9 |
| P | 305.09 | 209.20 | 318.44 | 324.91 | 330.74 |
| Mg | 16.09 | 20.56 | 24.53 | 29.31 | 33.80 |
| Na | 237.23 | 237.26 | 237.46 | 237.89 | 238.15 |
| K | 39.36 | 73.06 | 104.08 | 135.00 | 170.1 |
| Cu | 0 | 0 | 0 | 0 | 0 |
| Fe | 12.07 | 12.16 | 12.20 | 12.21 | 12.23 |
| Zn | 4.70 | 4.72 | 4.72 | 4.73 | 4.74 |
| Mn | 0.97 | 0.95 | 0.94 | 0.94 | 0.93 |
| physical characteristics | | | | | |
| Bread volume (cm3) | 82.32 | 82.54 | 82.76 | 82.95 | 83.23 |
| Loaf weight (g) | 242.8 | 242.2 | 241.1 | 235.9 | 230.4 |
| Specific volume (cm3/g) | 2.95 | 2.93 | 2.91 | 2.84 | 2.77 |

Values are means ± SD of three replicates.
Means in the same row with different letters are significantly different (p ≤ 0.05).
ND means not detected.

The results of volume, weight and specific volume are shown in Table 4. Table 5 shows the physical properties of the experimental bread samples. Bread samples had loaf volumes ranging from 230.40 to 242.80 cm3. The volume of the control sample (unfortified bread sample) was the highest (243.96 cm3), while the lowest volume (230.4 cm3) was recorded for bread samples containing 8 % DEFB powder. Substitution of wheat flour with higher levels (6 and 8%) DEFB powder caued significant decreases in the loaf volume compared to control samples without additions (Table 5). These results might be attributed to the dilution of gluten proteins by other proteins, as well as the mechanical disruption of the gluten network structure, which resulted in a significant reduction in the amount and size of CO2 bubbles in the experimental bread samples [3]. The specific volume is one of the most important factors in baked products since it influences bread's ultimate gas retention and thus product quality. The specific values of the evaluated bread samples ranged from 2.77 to 2.95 cm3/g (Table 4). Control samples and bread samples enriched with 2 and 4 % DEFB powder had the highest specific volumes .. This study suggests that adding 2 and 4 % DEFB powder to wheat flour had no effect on the specified values of the produced loaves. These findings might be attributable to gluten dilution as a result of the replacement procedure [3,19].

**Table 5:** Amino acids composition of composite flour bread (g/100 g protein).

| Amino acid | DEFB8% | DEFB6% | DEFB4% | DEFB2% | DEFB0 | FAO/WHO/ UNU, 2007 (1–2 yrs.) |
|---|---|---|---|---|---|---|
| Isoleucine | 3.79 | 3.79 | 3.82 | 3.82 | 3.83 | 3.1 |
| Leucine | 7.45 | 7.48 | 7.53 | 7.56 | 7.61 | 6.3 |
| Lysine | 1.5 | 1.6 | 1.67 | 1.72 | 1.79 | 5.2 |
| Cystine | 1.75 | 1.71 | 1.68 | 1.6 | 1.6 | |
| Methionine | 1.54 | 1.5 | 1.48 | 1.43 | 1.43 | |
| **Total sulfur amino acids** | 3.29 | 3.21 | 3.16 | 3.03 | 3.03 | 2.6 |
| Tyrosine | 4.2 | 4.12 | 4.09 | 3.95 | 3.95 | |
| Phenylalanine | 5.1 | 5.1 | 5.2 | 5.4 | 5.5 | |
| **Total aromatic amino acids** | 9.3 | 9.22 | 9.29 | 9.35 | 9.45 | 4.6 |
| Threonine | 2.6 | 2.65 | 2.7 | 2.72 | 2.75 | 2.7 |
| Valine | 5.01 | 5.01 | 5.01 | 5.03 | 5.03 | 4.2 |
| **Total essential amino acid** | 32.94 | 32.96 | 33.18 | 33.23 | 33.49 | |
| Histidine | 1.75 | 1.76 | 1.76 | 1.81 | 1.83 | 1.8 |
| Arginine | 3.07 | 3.11 | 3.14 | 3.19 | 3.24 | |
| Aspartic acid | 5.64 | 5.8 | 5.83 | 6.1 | 6.1 | |
| Glutamic acid | 32.5 | 32 | 31.8 | 31.47 | 31,23 | |
| Serine | 3.98 | 4.1 | 4.2 | 4.25 | 4.26 | |
| Proline | 12.54 | 12.48 | 12.27 | 12.12 | 12 | |
| Glycine | 4.05 | 4.32 | 4.32 | 4.33 | 4.34 | |
| Alanine | 3.53 | 3.47 | 3.5 | 3.5 | 3.51 | |
| Total non-essential amino acids | 66.97 | 67.04 | 66.82 | 66.77 | 66.51 | |
| Chemical score (CS) (%) | Lysine( 28.85) | Lysine( 30.77) | Lysine( 32.11) | Lysine (33.08) | Lysine( 34.42) | |
| First limiting amino acid | 28.846 | 30.7692 | 32.11538 | 33.0769 | 34.423 | |
| P-PER | 2.4733 | 2.49532 | 2.52117 | 2.54949 | 2.57219 | |

**Amino acids composition of composite flour bread (g/100 g protein)**

Amino acid compositions of the fortified and control breads (g/100 g protein) are presented in Table 5. In general, when DEFB powder was added to bread formulas, total essential amino acids significantly increased as compared to the control bread without addition (Table 5). The quantities of isoleucine, leucine, lysine, Phenylalanine threonine as well as total essential amino acids were increased when different concentrations of DEFB powder were added into wheat flour.

Bread samples enriched with DEFB powder higher values of essential amino acids than the standard pattern for children (1–2 years) (FAO/WHO/UNU, 2007) [26]. The lysine content of the experimental and control loaves, was found to be lower than the FAO/WHO/UNU recommended levels (2007). In the same time, the bread samples containing 6.0% and 8.0 % of DEFB powder provided 33.07% and 34.42 % of the recommended lysine level, respectively.

Lysine is still the limiting amino acid in the experimental bread samples, however fortification of wheat flour with DEFB powder reduced the lysine deficiency. Predicted protein efficiency ratio (P-PER) values of the experimental bread samples ranged from 2.47 to 2.57. The incorporation of DEFB powder into wheat flour significantly enhanced the PER values than the control sample without addition. The highest P-PER values (2.54 and 2.57) were recorded for bread samples incorporated with 6.0 % and 8.0 % DEFB powder, respectively. These findings are in good agreement with the previous results of Ali et al., 2022 who reported that the addition of different levels of soaked–dehulled moth bean into composite flour improved the P-PER values of produced breads.

**Sensory properties of bread fortified with different levels Dehulled- extruded Faba bean (DEFB) powder**

The sensory analysis is an important factor in determining the sensory features and overall acceptance of novel food items [3]. The sensory characteristics of experimental bread enriched with different quantities of DEFB powder are shown in Table 6. Experimental bread samples had appearance scores ranged from 7.73 to 8.80. The control sample and those containing 2 % DEFB powder, received the highest scores. The appearance of bread samples using 4 % and 6 % DEFB powder was significantly reduced ($p \leq 0.05$). The bread samples containing 8 % DEFB powder had the lowest appearance values (7.73). The bread samples received scores ranged from 7.80 to 8.80 on the taste scale. There were no significant ($p \geq 0.05$) changes in taste values between control samples and those samples containing 2 and 4 % DEFB powder. However, taste score gradually decreased with increasing incorporation of DEFB powder up to 6 % into composite flour. The aroma scores of the experimental bread samples ranged from 7.80 to 8.73. There were no significant (P≥0:05) changes in aroma scores between control bread and bread fortified with2 and 4 % DEFB powder; however, aroma scores for bread samples at higher fortification levels were considerably lower. The bread samples fortified with 8 % DEFB powder; received the lowest score. There were no significant (P≥0:05) changes in crumb color between control samples and those with 2 and 4 % DEFB powder. Higher concentrations of DEFB powder (6and 8%) resulted in significant ($P \leq 0.05$) decreases in crumd color scores. Control bread samples and those with 2 -6% DEFB powder achieved the highest overall acceptability scores 8.60 -8.87). There was no significant difference in overall acceptability ($p \geq 0.05$) among all bread samples up to 6 % DEFB powder addition. On the other hand, the bread sample supplemented with 8%DEFB powder powder received the lowest overall approval score (7.87).

**Table 6:** Sensory properties of bread fortified with different levels Dehulled- extruded Faba bean (DEFB) powder (n= 25).

| Sample | appearance | Taste | Aroma | Color | Overall acceptance |
|---|---|---|---|---|---|
| DEFB 0 | 8.93 | 9.00 | 8.93 | 8.90 | 9.00 |
| DDEFB 2% | 8.93 | 8.93 | 8.86 | 8.80 | 8.93 |
| DEFB 4% | 8.80 | 8.80 | 8.70 | 8.33 | 8.86 |
| DEFB 6% | 8.60 | 8.53 | 8.10 | 7.80 | 8.86 |
| DEFB 8% | 7.93 | 7.46 | 7.20 | 7.77 | 7.50 |

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