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Nutritional and Quality Aspects of Wheat Bread Fortified with Various 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 of addition various levels of dehulled - extruded faba bean powder (DEFB) on the nutritional properties and quality of wheat bread. *Design/methodology/approach* – Various quantities of DEFB powder (0%- 8%) were incorporated into wheat flour to make 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 assessed in terms of 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 Ca (230 mg/100 g), P (136.06 mg/100 g), Mg (198.00 mg/100 g), K (1325.00 mg/100 g), and Na (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% lowered the carbohydrate content considerably ($P \leq 0.05$) 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 greatest DEFB powder powder (8%) recorded the weakest scores.

Keywords: Faba Bean, Wheat, Bread, Functional Food, Amino Acids Protein, Sensory

1. 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 incorporation of legume flours to wheat flour is a viable approach for enhancing the nutritional content of cereal-based diets. Legumes possess amino acid profiles that are complimentary to cereal-based meals. [3, 4], and they also provide a lot of beneficial substances including fibre and phytochemicals [5].

Faba bean (Vicia faba L.), commonly known as fava bean, broad bean, and horse bean, is one of the world's oldest crops [6]. Faba bean seeds are high in protein, carbohydrates, fibre, and vitamins, and they actually reduce cholesterol levels [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]. Moreover, the presence of antinutritional substances such as trypsin inhibitors, condensed tannins, phytic acid, saponins, lectins, and favism-inducing factors reduces their nutritional value [11]. The elimination of these antinutrients is thus required for the optimal use of dietary beans in human nutrition. There are various traditional and scientific processing methods that can be used to minimize or remove the levels of these anti-nutrient factors through heat processing (boiling, cooking, autoclaving, or extrusion cooking) or pretreatments such as dehulling, soaking, germination, fermentation, and supplementation with various chemical and enzymes [11].

Extrusion is a common practical approach in the food business [12] for producing a variety of food items [13], starting from a diversity of protein-enriched components or blends. 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 of legume seeds has been used to eliminate antinutritional components and improve physicochemical characteristics. Extrusion of faba beans has been shown to have no influence on nutritional value, including protein, fat, and ash content [15]. Refined wheat flour is a poor source of protein due to the removing of the bran and germ parts [16]. It is therefore necessary to fortify wheat bread dough with different scource of protein in order to correct deficiencies of bread [3]. In this regard, to improve the nutritional and functional properties of bakery products, grape seeds [17] freeze dried plant powder [18], fennel seed [19], fermented split yellow pea [20] carrot and pumpkin [20], and soaked–dehulled moth bean seeds (SDMB) powder [3] have been used. 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.

2. Materials and Methods Materials

2.1. Raw Material and Chemicals

Dehulled Faba bean (Vicia Faba L.) was purchased in a 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.

2.2. Preparation Dehulled Extruded Faba Bean (DEFB) Powder

The Dehulled Faba bean seeds 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), 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.

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

2.3. Bread Making Process

The bread baking process was by the direct dough method [22]. The bread-making components were prepared as shown in Table 1. First, a proper amount of water was used to dissolve sugar, full cream milk powder, and salt. Wheat flour, instant active dry yeast, and bread improver were added to the dissolved components and blended in a Kenwood kitchen machine OWKHC29B0SI, 69036 (Kenwood Co., China) for 4 minutes on low speed, followed by 6 minutes on high speed.,. A farinograph (Brabender, Duisburg, Germany) was used to calculate the appropriate quantity of water at a consistency of 500 BU. A small amount of oil was added throughout the kneading phase. A clean Muslin cloth was used to cover the final dough. 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 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.

2.4. Evaluation of the Nutritional Attributes

Wheat flour, extruded-dehulled faba bean (DEFB) 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). Total Carbohydrate content was determined by estimated by subtracting the sum of the ash, proteins, crude fiber and fat contents from 100% [2], Energy value (kcal/100 g) was calculated using the following equation (according to Ali et al. [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. [23].

Amino acids were assayed by an automatic amino acid analyzerAAA400 (INGOS, Czech Republic) according to the standard procedures of Coda et al. [24].

2.5. Physical Properties of Bread Samples

Specific Volume

The specific volume of baked bread samples was then calculated as the volume/weight ratio by weighing baked samples and measuring their volume using the AACC No. 10-05.01 [25]. rapeseeds displacement method.

2.6. Sensory Evaluation (Acceptance and Preference Testing)

The sensory evaluation procedures wereapproved by the ethics Committee of the Auckland University of Technology study (AUTEC ethic application 16/340). To ensure the reliability of the results, panelists were instructed prior to the sensorial evaluation [3, 23]. 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. A panel of 15 judges from the Department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, Buraydah, Saudi Arabia, conducted sensory analysis to evaluate the organoleptic features of prepared bread samples.. The participants were asked to rate the bread samples' qualitative attributes: texture, odor, taste, color, and overall acceptability on a nine-point Hedonic scale, where 9 = Like extremely and 1 = Dislike excessively [2].

Statistical Analysis

All data were subjected to analysis using SPSS (version 20). Except for the sensory evaluation findings (n=15), the results were statistically examined in triplicate. To discriminate between treatments, a one-way analysis of variance (ANOVA) was performed at a 5% significant level, and means were compared using Duncan's multiple range test.

3. Results and Discussion

3.1. Chemical Composition (g per 100 g Dry Weight Basis) and Minerals Content (mg/100g) of Wheat Flour, Dehulled - Extruded Faba Bean (DEFB) Powder

Proximate Composition and Mineral Content of Dehulled-Extruded Faba Bean Powder and Wheat Flour.

Table 2 shows the results of the chemical composition and mineral composition of dehulled-extruded faba bean (DEFB) powder and wheat flour. The protein level of DEFB powder was 32.50 g/100 g, which is 2.90 times greater than wheat flour. The protein content of faba beans ranges from 20% to 41%, depending on the variety [9, 26]. The protein content of the dried fava beans ranged from 26 to 33% on a dry weight basis [27]. 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 a source of protein and minerals. Faba bean (Vicia faba L.) is a significant source of proteins and also contains starch, fiber, bioactive compounds, lecithin, vitamins, and minerals [26]. These results are similar to those obtained by Labba et al. [27] 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 ca (230 mg/100 g), P (136.06 mg/100 g), Mg (198.00 mg/100 g), K (1325.00 mg/100 g) and Na (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, 28]. These findings showed that DEFB powder can effectively be utilized as a rich source of protein, carbohydrates and minerals.

3.2. 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, [29] (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, [29] (1–2 yrs.) reference values. As a result, Dehulled-extruded Faba bean (DEFB) powder protein might very well supplement low-lysine protein sources such as wheat flour proteins. Non-essential amino acids accounted for 62.78 percent of total amino acid composition. The major non-essential amino acids in dehulled-extruded faba bean (DEFB) powder protein were arginine, aspartic acid, and glutamic acid, with contents of 8.06 percent, 11.50 percent, and 18.30 percent, respectively, which were 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 [4]. Most cereal grains, on the other hand, contain a low quantity of lysine but extremely high quantities of sulfur-containing amino acids, which is why these two food groups are seen to be complimentary in a plant-based diet [27].

Table 2. *Chemical Composition (g per 100 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.

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, [29] (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.
Means in the same row with different letters are significantly different ($p \leq 0.05$).
ND means not detected.

3.3. Proximate Composition (g Per 100 g), Mineral Content (mg/100g), and Physical Properties of Bread Fortified with Different Amounts of DEFB

Table 4 shows the chemical composition (g per 100 g dry weight basis), mineral content (mg/100g), and physical attributes of bread enriched with varying quantities of dehulled-extruded faba bean (DEFB). 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 content, on the contrary the un-fortified bread had the least (11.58%) protein. Protein content of bread samples significantly ($P \leq 0.05$) 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 [30]. There were no statistically significant changes in fat and fiber contents between the fortified and unfortified bread samples ($P \geq 0.05$). 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 ($P \leq 0.05$) in carbohydrate content compared to the control samplewithout 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 where as 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 ($P \geq 0.05$) 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 grains [30, 31].

The results of volume, weight and specific volume are shown in Table 4 shows the physical properties of the experimental bread samples. Bread samples had loaf volumes ranging from 230.40 to 242.80 cm^3. The volume of the control sample (unfortified bread sample) was the highest (243.96 cm^3), while the lowest volume (230.4 cm^3) 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 findings might be due to gluten protein dilution by other proteins, as well as mechanical disturbance of the gluten network structure, which resulted in a considerable decrease in the volume and size of CO_2 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 cm^3/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, 23].

Table 4. *Chemical Composition (g per 100 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

Components	Samples				
	DEFB0	DEFB2%	DEFB4%	DEFB6%	DEFB8%
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 (cm^3)	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 (cm^3/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 ($p \leq 0.05$).
ND means not detected.

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

Amino acid	DEFB8%	DEFB6%	DEFB4%	DEFB2%	DEFB0	FAO/WHO/ UNU, [29] (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	

3.4. 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 fortified with DEFB powder had greater essential amino acid levels than the recommended pattern for children (1–2 years) [29]. The amounts of lysine in the experimental and control loaves were found to be lower than the FAO/WHO/UNU approved values [29]. Likewise, bread samples containing 6.0 and 8.0 percent DEFB powder supplied 33.07 and 34.42 percent of the necessary lysine amount, 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., [3] who reported that the addition of different levels of soaked–dehulled moth bean into composite flour improved the P-PER values of produced breads.

3.5. Sensory Characteristics of Bread Fortified with Various Levels of 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 ($P \geq 0.05$) changes in aroma scores between control bread and bread fortified with 2 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 ($P \geq 0.05$) changes in crumb color between control samples and those with 2 and 4% DEFB powder. Higher concentrations of DEFB powder (6 and 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	8.93	8.9	9
DDEFB 2%	8.93	8.93	8.86	8.8	8.93
DEFB 4%	8.8	8.8	8.7	8.33	8.86
DEFB 6%	8.6	8.53	8.1	7.8	8.86
DEFB 8%	7.93	7.46	7.2	7.77	7.5

Means in the same row with different letters are significantly different ($p \leq 0.05$).

4. Conclusion

The current study's major findings suggested that incorporation of 2–4% dehulled extruded Faba bean (DEFB) powder into wheat flour improved the nutritional and qualitative aspects of wheat bread.

References

[1] Carocho, M., Morales, P., Ciudad-Mulero, M., Fernandez-Ruiz, V., Ferreira, E., Heleno, S., Rodrigues, P., Barros, L., C. F. R. Ferreira, I., 2020. Comparison of different bread types: Chemical and physical parameters. Food Chem. 310, 125954. https://doi. org/10.1016/j.foodchem.2019.125954.

[2] Ali, R. F., El-Anany, A. M., Mousa, H. M. and Hamad, E. M. (2021), “Nutritional and sensory characteristics of bread enriched with roasted prickly pear (Opuntia fcus-indica) seed four”, Food Function, Vol. 11 No. 3, pp. 2117-2125, doi: 10.1039/C9FO02532D.

[3] Ali, R. F., Althwab, S. A., Alfheeaid, H. A., El-Anany, A. M., Alhomaid, R. M. and Alharbi, H. F. (2022). Nutritional and quality characteristics of wheat bread fortified with different levels of soaked–dehulled moth bean (Vigna aconitifolia) seeds powder, British Food Journal, Vol. 124 No. 5, 2022 pp. 1537-1550.

[4] Boye, J., Zare, F., & Pletch, A. (2010). Pulse proteins: Processing, characterization, functional properties and applications in food and feed. Food Research International, 43, 414e431.

[5] Asif, M., Rooney, L. W., Ali, R., & Riaz, M. N. (2013). Application and opportunities of pulses in food system: A review. Critical Reviews in Food Science and Nutrition, 53, 1168e1179.

[6] Mínguez, M. I., & Rubiales, D. (2021). Faba bean. In V. O. Sadras & D. F. Calderini (Eds.), Crop Physiology Case Histories for Major Crops (pp. 452–481). Academic Press. https://doi.org/10.1016/B978-0-12- 819194-1.00015-3

[7] Macarulla, M. T., Medina, C., De Diego, M. A., Chávarri, M., Zulet, M. A., Martínez, J. A., et al., 2001. Effects of the whole seed and a protein isolate of faba bean (Vicia faba) on the cholesterol metabolism of hypercholesterolaemic rats. Brit. J. Nutrition 85, 607–614.

[8] Abu-Reidah IM, del Mar Contreras M, Arráez-Román D, Fernández-Gutiérrez A, Segura-Carretero A. UHPLC-ESI-QTOF-MS based metabolic profiling of Vicia faba L. (Fabaceae) seeds as a key strategy for characterization in foodomics. Electrophoresis 2014; 35 (11): 1571–81.

[9] Mahmoud, A. H. and El Anany, A. M. (2014), “Nutritional and sensory evaluation of a complementary food formulated from rice, Faba beans, sweet potato flour, and peanut oil”, Food and Nutrition Bulletin, Vol. 35 No. 4, pp. 403-413, doi: 10.1177/156482651403500.

[10] Khazaei, H. and Vandenberg, A. (2020). Seed Mineral Composition and Protein Content of Faba Beans (Vicia faba L.) with Contrasting Tannin Contents. Agronomy 2020, 10, 511; doi: 10.3390/agronomy10040511.

[11] Revilla, I (2015) Chapter 40: Impact of Thermal Processing on Faba Bean (Vicia faba) Composition. Processing and Impact on Active Components in Food. Pages 337-343.

[12] Assatory, A., Vitelli, M., Rajabzadeh, A. R., Legge, R. L., 2019. Dry fractionation methods for plant protein, starch and fiber enrichment: a review. Trends Food Sci. Technol. 86, 340–351. doi: 10.1016/j.tifs.2019.02.006.

[13] Philipp, C., Oey, I., Silcock, P., Beck, S. M., Buckow, R., 2017. Impact of protein content on physical and microstructural properties of extruded rice starch-pea protein snacks. J. Food Eng. 212, 165–173. doi: 10.1016/j.jfoodeng.2017.05.024.

[14] Agarwal S, Chauhan ES, Extrusion processing: The effect on nutrients and based products. The Pharma Innovation Journal. 2019; 8 (4): 464-470.

[15] Nosworthy, M. G., Medina, G., Franczyk, A. J., Neufeld, J., Appah, P., Utioh, A., Frohlich, P., & House, J. D. (2018). Effect of processing on the in vitro and in vivo protein quality of beans (Phaseolus vulgaris and Viciafaba). Nutrients, 10, 671. https://doi.org/10.3390/nu10060671

[16] Jewell D, Young G (2001) Interventions for treating constipation in pregnancy. Cochrane Database Syst Rev 2001 (2): CD001142.

[17] Majzoobi, M.; Azadmard-Damrichi, S.; Peighambardoust, S. H.; Aghamirzaei, M. Effects of grape seed powder as a functional ingredient on flour physicochemical characteristics and dough rheological properties. J. Agric. Sci. Technol. 2015, 17, 365–373.

[18] Ranawana, V.; Raikos, V.; Campbell, F.; Bestwick, C.; Nicol, P.; Milne, L. and Duthie, G. (2016). Breads Fortified with Freeze-Dried Vegetables: Quality and Nutritional Attributes. Part 1: Breads Containing Oil as an Ingredient. Foods 2016, 5, 19; doi: 10.3390/foods5010019.

[19] Ahmad, B. S.; Straumite, E.; Sabovics, M.; Kruma, Z.; Merah, O.; Saad, Z.; Hijazi, A.; Talou, T. Effect of addition of fennel (Foeniculum vulgare L.) on the quality of protein bread. Nutr. Health 2017, 71, 509–514.

[20] Bourré, L.; McMillin, K.; Borsuk, Y.; Boyd, L.; Lagassé, S.; Sopiwnyk, E.; Jones, S.; Dyck, A. and Malcolmson, L. (2019). Effect of adding fermented split yellow pea flour as a partial replacement of wheat flour in bread. Legume Science. 2019; 1: e2., 1-11. https://doi.org/10.1002/leg3.2

[21] Zavalishina, O. M.; Kuznetsova, T. A. and Korneeva, A. V. (2021). The results of evaluating the use of vegetable additives in bread production. IOP Conf. Series: Earth and Environmental Science 640 (2021) 062009 IOP Publishing doi: 10.1088/1755-1315/640/6/062009.

[22] Bredariol, P., Spatti, M., & Vanin, F. M. (2019). Different baking conditions may produce breads with similar physical qualities but unique starch gelatinization behaviour. LWT, 111, 737-743. http:// dx.doi.org/10.1016/j.lwt.2019.05.094

[23] Althwab, S. A., Alhomaid, R. M., Ali, R. F. M., El-Anany, A. M. and Mousa, H. M. (2021), "Effect of migratory locust (Locusta migratoria) powder incorporation on nutritional and sensorial properties of wheat flour bread", British Food Journal. doi: 10.1108/BFJ-11-2020-1052.

[24] Coda, R., Varis, J., Verni, M., Rizzello, C. G. and Katina, K. (2017), "Improvement of the protein quality of wheat bread through faba bean sourdough addition", LWT-Food Science and Technology, Vol. 82, pp. 296-302, doi: 10.1016/j.lwt.2017.04.062.

[25] AACC. Method 10-05.01 (2000). Guidelines for Measurement of Volume by Rapeseed DisplacementApproved Methods of Analysis, 11th ed.; AACC International: St. Paul, MN, USA, 2000.

[26] Dhull, S. B., Malik, T., Kaur, R., Kumar, P., Kaushal, N. and Singh, A. 2021. Banana starch: properties illustration and food applications - a review. Starch 73 (1): article ID 2000085.

[27] Labba, I. C. M., Frøkiær, H., & Sandberg, A. S. (2021). Nutritional and antinutritional composition of fava bean (Viciafaba L., var. minor) cultivars. Food Research International, 140, 110038.

[28] USDA (US Dept of Agriculture). (2021). Food Data Central (Nutrient Database). https://fdc.nal.usda.gov/ (accessed on January 26, 2021).

[29] FAO/WHO/UNU (2007), "Protein and amino acid requirements in human nutrition: report of an FAO/ WHO/UNU Expert Consultation", WHO Technical Report Series No. 935, World Health Organization, Geneva.

[30] Robinson, G. H. J.; Balk, J.; Domoney, C. Improving pulse crops as a source of protein, starch and micronutrients. Nutr. Bull. 2019, 44, 202–215. [CrossRef] [PubMed].

[31] White, P. J.; Broadley, M. R. Biofortification of crops with seven mineral elements often lacking in human diets–iron, zinc, copper, calcium, magnesium, selenium and iodine. New Phytol. 2009, 182, 49–84.