التركيب الكيميائي والقيمة الغذائية لبعض المنتجات الخالية من الجلوتين والمدعمة ببعض البقوليات

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Abstract

The current study aimed to determine the chemical composition and nutritional value of toast bread and crackers fortified with 10% and 20% (beans and lentil) powders as a natural source of protein. Likewise, the physical properties and sensory characteristics of toast bread and crackers were assessed. The results showed that protein, fiber and total carbohydrates values in toast bread fortified with 10% and 20% (beans and lentil) powder were significantly higher than the control at ($P< 0.01$) that were recorded (18.30%, 2.27% and 72.86%); respectively in toast bread with 20% (beans and lentil) powder. The statistical analysis showed that the values of ash, crude fat and calories were highly significant between all the studied toast bread and control toast bread at ($P< 0.01$). On the other hand, phosphorous and iron of toast bread fortified with 10% and 20% (beans and lentil) powders were recorded significantly higher than the control toast bread. Also, The results showed that protein, fiber and total carbohydrates values in crackers fortified with 10% and 20% (beans and lentil) powder were high significantly than the control at ($P< 0.05$), which were recorded (10.16%, 1.49% and 84.89%); respectively in crackers with 20% lentil, 20% beans and 10% lentil powders. While the statistical analysis showed that the values of ash, crude fat and calories were highly significant between all studied crackers and control crackers at ($P< 0.01$). On the other hand, the phosphorous, iron and magnesium of crackers fortified with 10% beans powder were recorded significantly higher than the control crackers. Likewise, the data revealed that the best score in overall acceptability was in toast bread and crackers fortified with 20% lentil powder. So the use of (beans and lentils) in dietary products can be recommended as functional food and enrichment of diets for better utilization of protein.

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Keywords
Chemical composition, minerals content, beans, lentil, bread, crackers.

Introduction

Celiac disease (CD) is a genetic autoimmune disease. It is induced by the consumption of gluten, which is found in wheat, barley, rye and sometimes oats. When celiac patients eat foods provided with gluten, their immune system responds by destructing the finger-like villi of the small intestine, according to **(Neveen and Amira 2018).**

Food fortification, defined as the addition of one or more vitamins and minerals to commonly consumed foods, is a proven and cost-effective intervention for addressing micronutrient deficiencies by improving the nutritional quality of the food supply. There is strong evidence that food fortification has led to a substantial increase in the availability of some nutrients, including iodine, iron, folate and vitamin A in several regions **(Mkambula *et al.*, 2020).**

Gluten-free bakery products like biscuits, pasta, bread and cake are a growing trend in the domestic and international markets, contributing to health and wellness, especially for the celiac public **(Priscila *et al.*, 2020).**

Gluten-free products are usually protein-free products; the removal of proteins deprives the raw material of minerals and vitamins, which negatively impacts its nutritional value. This is the reason why gluten-free products should be supplemented by raw materials naturally free of gluten, and rich in additional nutrients **(Jehan and Abol-Ela 2019).**

Bread is a staple food, widely consumed in large quantities worldwide, with an important role in human nutrition. Due to the increased awareness of health issues, the bakery industry is moving to provide functional and healthy foods, mainly via fortification with satiating and active ingredients, such as proteins, fibers, minerals, vitamins, and bioactive peptides in response to an increasingly demanding consumer. The incorporation of ingredients that exhibit functional properties, in addition to traditional nutrients, is an interesting alternative to the development of innovative bakery foods **(Carla *et al.*, 2019).**

Hess *et al.*, (2016) define snacks are small portions of food usually consumed to satisfy cravings between meals. Crackers are a form of crisp bread generally prepared from wheat flour and fat,

and a popular snack. The popularity of crackers is not restricted to a specific age group, gender or nationality. The market demand for snacks is steadily increasing due to busy lifestyles and hectic schedules that necessitate consumers to supplant traditional meals with healthy snack options. A recent survey published by Mondelez International showed consumers prefer snack foods that are high in protein and dietary fiber, but low in fat, salt, cholesterol, sugar and calories. The demand for healthy snacks presents an opportunity to increase the nutritional value of crackers **(Escobedo *et al.*, 2021).**

Legumes play an important role in many diets all over the world and are especially important in developing and third world countries in Africa, Latin America and Asia. However, new research is changing the label of legumes to "health food", encouraging their inclusion in the diets of even affluent people **(Messina, 2016) & (Kouris-Blazos and Belski 2016).**

Beans contain healthy nutrition for the human body, such as complex carbohydrates, high fibre, low fat, non-cholesterol, vitamins, mineral, and low sodium. Beans flour is chosen as the main ingredient for business since it has a high level of protein. Moreover, Lingga adds that bean contains energy, vitamin E, minerals, and acidic fat. Bean is a type of bean with excellent antioxidants like zinc, sulphur, Mangan, selenium, and omega-3. The selenium in beans helps people reduce anxiety, sensitivity, and depression. Mung bean is rich with niacin which allows the brain produces serotonin. Also, the bean has a high rate of iron which helps control the nervous system **(Siti *et al.*, 2019).**

Lentil has a high substance of fundamental amino acids and is a decent source of bioactive fundamental minerals, including significant supplements (K, P, Ca, Mg, Na) and minor components (Fe, Zn, Cu, Mn). It can be considered an environmentally unadulterated item. Rather than numerous different food varieties, lentils lose a few nutrients following heating during cooking. As a result of the high nutritional value of lentils, more emphasis should be placed on incorporating them into the diet **(Harshita *et al.*, 2022).**

The objective of this study was to determine the chemical composition and nutritional value of some gluten–free products fortified with legumes.

Materials and Methods

Materials

Source of samples

Two kg of beans *(Sakha1)* and lentils *(Lens culinaris, L.)* were obtained from Agriculture Research Center, Giza, Cairo, Egypt. season 2021.

Gluten-free flour, dry yeast and salt (sodium chloride), sugar powder, baking powder and corn oil were purchased from the local market, in Assiut city, Egypt.

Preparation of materials

Soaking

Beans and lentils were manually cleaned from dust and foreign materials and then soaked in water for 12 hours at 25°c, seeds to water ratio of 1:5 (W/V) was used. The imbibed water was discarded. The soaked seeds were washed twice with tap water followed by rinsing with distilled water and then dried at 55°c for 30 h.

Germination

The presoaked beans and lentils (12 hours) were spread on wet filter paper in a stainless steel basket. The germinated beans and lentil ranged from 20 to 23°c during the 72h of spouting. Then germinated legumes (beans and lentils) were dried at 55°c for 30h. Beans and lentil samples were ground in a laboratory waily mill to pass through a 40 mesh screen. Then, the ground samples were stored in a polyethylene bag at 5°c until required for analysis.

Technological Process

The bread formula and ingredients

Bread dough was prepared according to **(Fatma and Safaa 2015).** The ingredients of the formula are presented in **Table (1).** The bread was fortified with 10% and 20% beans and lentil powder.

Table (1): Bread Formula*

Ingredients	Control	Blends of bread	
		10%	20%
Gluten-free flour(g)	100	100	100
Beans powder(g)	-	10	20
Lentil powder(g)	-	10	20
Sodium chloride(g)	1	1	1
Dry yeast(g)	0.5	0.5	0.5
Water(ml)	60	60	60

***Fatma and Safaa (2015).**

Dough preparation

Gluten-free flour, water, salt (sodium chloride), dry yeast, beans and lentil powder were added at the expense of gluten-free

flour using the proportion given in **Table (1)** were mixed in the kneader dough for 10 minutes. Fermentation took135 minutes at 30°c ± 2 and relative humidity was 80 – 85 %.

Preparation of bread

The dough was pressed to release CO2 and molded with corn oil (about 1.5g oil) in pans with dimensions: length of 12 cm, width 6 cm and height of 8cm. Baking was carried out in an electric oven at 230-240°c for 20-25 minutes. The bread top was subjected to a wet brush in order to enhance the crust appearance immediately after removing from the oven **(Mostafa and Othman 1986).**

Preparation of different blends of bread

Blends of bread were prepared using gluten-free flour as control and fortified with 10% and 20% beans and lentil powder.

The bread samples were executed as follows:

***Sample (1):** Control sample 100% of gluten-free flour.
***Sample (2):** Bread fortified with 10% beans powder.
***Sample (3):** Bread fortified with 20% beans powder.
***Sample (4):** Bread fortified with 10% lentil powder.
***Sample (5):** Bread fortified with 20% lentil powder.

Crackers formula and ingredients

The crackers dough was prepared according to **(Han *et al.*, 2010).** The ingredients of the formula are presented in **Table (2).** The crackers were fortified with 10% and 20% beans and lentil powder.

Table (2): Crackers Formula*

Ingredients	Control	Blends of crackers	
		10%	20%
Gluten-free flour(g)	100	100	100
Beans powder(g)	-	10	20
Lentil powder(g)	-	10	20
Sodium chloride(g)	2	2	2
Sugar powder(g)	2	2	2
Backing powder(g)	0.2	0.2	0.2
Corn oil(ml)	5	5	5
Water(ml)	40:60	40:60	40:60

***Han *et al.*, (2010).**

Dough preparation

For making crackers, the procedure by **(Han *et al.*, 2010).** Was followed, with some modifications. Crackers were prepared from a

blend of gluten-free flour and (beans and lentil) powder using the ingredients of crackers shown in **Table (2).** Sugar powder and corn oil were mixed for 3-4 min in a Hobart mixer, at (25°c). Then add salt and water were mixed in a mixer Moulinex, mixer model Supermix150 for 1 minute.

Dry ingredients like gluten-free flour and baking powder were progressively added to the mixture and mixed at a low speed and continuing to mix for 3 minutes to make the dough. After this the dough of crackers was left to rest for 15 minutes.

Preparation of crackers

The dough was sheeted to a thickness of about 3mm. The sheeted dough was cut into small round pieces & stars and flattened for 10 seconds using a 45mm diameter cutter and manual equipment then baked on an aluminum tray in an electric oven at 160°c for 10 min. The crackers were cooled and stored in polyethylene bags until analysis.

Preparation of different blends of crackers

Blends of crackers were prepared using gluten-free flour as control and that fortified with 10 % and 20% beans and lentil powder.

The crackers samples were executed as follows:

***Sample (1):** Control sample 100% of gluten-free flour.
***Sample (2):** Crackers fortified with 10% of beans powder.
***Sample (3):** Crackers fortified with 20% of beans powder.
***Sample (4):** Crackers fortified with 10% of lentil powder.
***Sample (5):** Crackers fortified with 20% of lentil powder.

Methods

Determination of chemical composition

The moisture, protein, crude fat and ash contents of the investigated toast bread and crackers made of gluten-free flour and gluten-free flour fortified with (10% and 20%) beans and lentil powder, all these samples were determined according to the methods described by **(A.O.A.C. 2010).**

Carbohydrates content

The total carbohydrate content of the investigated toast bread and crackers made of gluten free flour and gluten free flour fortified with (10% and 20%) beans and lentil powder was calculated by difference using **(A.O.A.C. 2010).** The caloric value was calculated according to the method of **(Seleet 2010).**

Total Calorics= fat x 9 + protein x 4 + total carbohydrates x 4.

Determination of minerals content

The total content of minerals was carried out using a mixture of perchloric and Nitric acid (HCIO4 / HNO3) according to (Inductively Coupled Plasma Emission Spectromet) According to **(Isaac and Johnson 2002),** The elements **(**Magnesium (Mg) and Iron (Fe)**)** were determined using the ICP (ICAP6200).

Phosphorus (P) was estimated using by GBC Atomic Absorption 906 A according to the procedure reported by **A.O.A.C., (2010).**

Physical evaluation of bread

Loaves were weighed in grams after two hours of baking and the volume (ml) of each loaf was determined using the seed displacement method using clover seeds. The specific loaf volume (S.L.V) and loaf weight were calculated according to **(Mostafa and Othman 1986)** using the following equation:

$$S.L.V. = \frac{\text{Volume (ml)}}{\text{Weight (g)}}$$

Physical evaluation of crackers

Crackers were evaluated for height (cm), width (cm), spread ratio and spread factor, These crackers were used for the evaluation from each of the studied crackers and averages were recorded. The spread ratio and spread factor were calculated according to **(Natthakarn *et al.*, 2009)** using the following equation:

$$\text{Spread ratio} = \frac{\text{Width}}{\text{Height}}$$

$$\text{Spread factor} = \frac{\text{Spread ratio of sample}}{\text{Spread ratio of control}} \times 100$$

Sensory evaluation of toast

Sensory evaluation of toast bread for the colour (crust and crumb), graining, texture, taste, odor and overall acceptability of toast bread were by using the scoring system according to **(Mostafa and Othman 1986).** In order to determine consumer acceptability. A numerical hedonic scale ranges from 1 to 10 (1 is very bad and 10 for excellent). Ten experienced judges from the staff of the Nutritional and Food Science Department, Faculty of Specific Education, Assiut University, Egypt and some consumers.

Sensory evaluation of crackers

Sensory evaluation for the taste, color, texture, and overall acceptability of crackers were done in order to determine consumer acceptability. A numerical hedonic scale ranges from 1 to 10 (1 is very bad and 10 for excellent). Was used for sensory evaluation **(Chopra *et al.*, 2018).** Ten experienced judges from the staff of the Nutritional and Food Science Department, Faculty of Specific Education, Assiut University, Egypt and some consumers.

Statistical analysis

Data were analyzed by applying F- test using SPSS program version 16 and the data was analyzed with analysis of variance (ANOVA) procedures by using the **(MSTAT- C 1983)** statistical software package **(Russell 1983).** Where the F- test showed signification differences among mean **(Duncan 1995)** multiple range tests were performed at the 0.05 level of probability to separate the mean. The correlation between malondialdehyde and total antioxidant capacity was performed using a person's rank correlation coefficient.

Results and Discussion

Gross chemical composition and caloric value of gluten-free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders

The data in **Table (3)** revealed a significant variation at ($P< 0.01$) in protein, fiber and total carbohydrate content in toast bread fortified with (beans and lentil) powder when compared with gluten-free toast bread (control). Results indicated that gluten-free flour toast bread and fortified toast bread with natural sources of protein ranged from 12.83% to 18.30% on a dry weight basis (D.W) and 7.41% to 10.48% on a wet weight basis (W.W). On the other hand, crude fiber was recorded at 1.79% in toast bread with 10% beans powder and 1.27% in toast bread with 20% lentil on a dry weight basis (D.W) and 0.52% in toast bread with 10% lentil powder and 1.47% in toast bread with 20% beans powder on a wet weight basis (W.W) and crude fat were recorded the value of a low value (3.98%-6.65%) in (W.W) and (D.W); respectively in toast bread fortified with 10%, 20% beans and powder. Total carbohydrates were recorded high values (46.38%, 72.86%) in toast bread fortified with 20% beans powder on (W.W) and (D.W). While, the caloric value was recorded as a high value in toast bread fortified with 10% lentil powder 443.14 K.cal/100g on a dry weight basis (D.W). Our results are in agreement with **(Bouhlal *et al.*, 2019) & (El-Dreny and El-Hadidy 2020)** showed that beans flour

supplemented with gluten-free flour significantly improved the chemical composition (crude protein, ash and crude fiber) due to beans seeds is rich in ash, protein and dietary fiber. **(Rosa *et al.*, 2021)** reported an increase in protein, ash and crude fiber in fortified bread. While, total carbohydrates and caloric value were decreased. The increase in protein, ash and fiber contents in pan bread samples was due to their higher contents in beans flour than in gluten-free flour. The decrease in total carbohydrates and caloric value in bread samples was due to their higher fiber contents in beans seeds flour.

Gross chemical composition of gluten-free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders

The data in **Table (4)** revealed a statistically significant difference at ($P< 0.05$) in protein, fiber and total carbohydrates content in crackers fortified with 10% and 20% (beans and lentil) powders when compared with gluten-free crackers (control). Results indicated that gluten-free flour crackers and fortified crackers with natural sources of protein ranged from 7.68% to 10.16% on a dry weight basis (D.W) and 7.53% to 10.00% on a wet weight basis (W.W). On the other hand, crude fiber was recorded at 1.25% in crackers with 10% beans powder and 1.16% in crackers with 20% lentil on a dry weight basis (D.W) and 0.77% in crackers with 10% lentil powder and 1.44% in crackers with 20% beans powder on a wet weight basis (W.W) and crude fat were recorded a low values (5.53%-5.64%) in (W.W) and (D.W); respectively in crackers fortified with 10% lentil powder. Total carbohydrates were recorded at high values (83.25%, 84.89%) in crackers fortified with 10% lentil powder (W.W) and (D.W). While, the caloric value was recorded as a high value in crackers fortified with 10% beans powder 424.55 K.cal/100g. Our results are in agreement with **(Zeinab 2017) and (Manu *et al.*, 2022)** who reported that crackers supplemented with bean powder led to increased protein content, fat, ash and fiber compared with control. The protein content of the crackers was raised significantly, which might be attributed to the high-protein holding capacity of the bean powder. As a increase in the moisture content of the crackers was observed by increasing the beans powder percentage increased the total lipid of the crackers due to the oil holding capacity of the beans powder. Likewise, protein content, ash and fibers are higher in the fortified crackers compared to the control due to the

nutritional values of beans. Consequently, the total carbohydrates and moisture decreased significantly by increasing the amount of the beans in the crackers. **(Annalisa and Paolo 2021)** showed that crackers supplemented with lentil powder led to increased protein content due to lentils being a rich source of protein that is more present in lentil powder than in gluten-free flour, ash, fat and fiber. While total carbohydrates were decreased compared with control due to lentil content compared with gluten-free flour. While, gluten-free flour contained the highest level of carbohydrates compared with lentils powder. Consequently, the moisture decreased significantly by increasing the lentil in the crackers.

Minerals content of gluten-free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders

The data tabulated the minerals content of gluten-free flour bread and fortified bread with 10% and 20% (beans and lentil) powders in **Table (5).** The data in **Table (5)** recorded highly significant differences at ($p< 0.05$) and ($p< 0.01$) between control toast bread and fortified toast bread in P, Fe and Mg contents. The highest values of phosphorous, magnesium and iron were (145.52 mg/100g, 63.26 mg/100g and 30.38 mg/100g) in toast bread fortified with 20% beans powder and toast bread fortified with 20% lentil. On the other hand, the lowest values were (126.62 mg/100g, 21.25 mg/100g and 43.45 mg/100g) in toast bread fortified with 10% lentil, 10% beans and 20% lentil powders. These results are in agreement with those of **(Ali and İlyas 2019) & (Ahmed *et al.*, 2021)** they found that bread supplemented with deferent levels of lentil seeds flour showed an increase in phosphorous, iron and magnesium due to partially defatted seed flour containing a higher value of phosphorous, iron and magnesium compared to gluten-free flour. Also, **(Bouhlal *et al.*, 2019)** mentioned that the content of iron in pan bread substitute with 20% lentil seeds flour was increased compared with gluten free flour pan bread (control) due to lentil seeds having a high amount of iron and medium value in phosphorous and magnesium. Consequently, the antioxidant activity was increased which can help to heal several pathologies that the main causes of oxidative stress.

Minerals content of gluten-free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders

The data tabulated the mineral content of gluten free flour crackers and fortified crackers with 10% and 20% (beans and lentil) powders in **Table (6).** The data in **Table (6)** showed statistically highly significant differences ($p< 0.05$) and ($p< 0.01$) between control crackers and fortified crackers in P, Fe and Mg contents. The highest values of phosphorous, magnesium and iron were (187.51mg/100g, 126.92mg/100g and 34.24mg/ 100g) in crackers fortified with 20% lentil powder and crackers fortified with 10% beans powder. On the other hand, the lowest values were (126.48 mg/100g, 52.07 mg/100g and 16.93 mg/100g) in crackers fortified with 10% lentil, 10% beans and 20% lentil powders; respectively. These results are in agreement with those of **(Zeinab 2017)** who reported that crackers fortified with15% bean showed an increase in phosphorous, iron and magnesium contents compared with the control sample due to exhibiting high phosphorous, iron and magnesium concentrations. Generally, all minerals increased significantly by increasing the bean in the crackers compared to control. Also, **(Sinem and Fatma 2022)** showed that crackers substituted with 10% lentil powder led to increased phosphorous, iron and magnesium contents compared with control. On the other hand, **(Manu *et al.*, 2022)** found that the addition of beans and lentil flours to gluten free products caused changes in the minerals content of crackers, were phosphorous, iron and magnesium were recorded high values compared with control. (gluten-free flour crackers).

Physical characteristics of gluten-free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders

The physical characteristics of gluten-free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders are outlined in **Table (7).** The data in **Table (7)** showed that there were statistically significant differences ($P< 0.01$) between weight (g) and volume (ml). The data showed that the highest value of weight and volume in toast bread fortified with 20% beans powder were (181g) and (427ml) when compared with other treatments. On the other hand, toast bread fortified with 10% lentil powder recorded the lowest value of weight and volume (150g) and (383ml). Specific loaf volume was decreased in toast bread fortified with 20% beans and 20% lentil powders when compared to the control. These results in agreement with **(El-Dreny and El-Hadidy 2020) & (Ahmed *et al.*, 2021)** they mentioned that a similar effect was

observed with toast bread density while, the decrease in specific volume was due to the absence of gluten content in the lentil bread. Lower specific volume values of bread with the addition or partial replacement of gluten-free flour with non-glutinous flour due to the absence of gluten content in the additives which gives a less active gluten network and gas trapping, which might be strongly related to higher bread hardness.

Physical characteristics of gluten-free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders

Physical characteristics of gluten-free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders in **Table (8)**. The data in **Table (8)** outlined non-significant differences between thickness (cm), spread ratio and factor (%) of crackers fortified with 10% and 20% (beans and lentil) powders. And**,** width was recorded non-significant difference in all treatments and control. Also, the data showed that non-significant differences in spread ratio and spread factor in crackers fortified with 20% lentil powder were 8.29 and 101.84% when compared with other treatments. On the other hand, crackers fortified with 20% beans powder recorded the lowest value of spread ratio and spread factor 7.44 and 91.40%; respectively. These results are in agreement with **(Millar *et al.*, 2017)** who recorded that expansion in thickness, width, spread ratio and spread factor was slightly increased with increasing level of beans powder compared with control. These variations in baking properties may be due to the changes in the quality and quantity of bean powder which added to the ingredients. On the other hand, **(Jennifer 2010)** stated that in crackers fortified with lentil powder were viscosity of dough reduces as the addition of lentil flour and the spread rate increases. It is noticed that, spread ratio increases with the addition of lentil flour and with the increase in the protein content of the crackers and it could have been affected by the absence of gluten.

Sensory evaluation of gluten free-flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders

Sensory characteristics of gluten-free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders are presented in **Table (9) and Figures (1A-E).** The data in **Table (9)** revealed that there a statistically highly significant difference at ($p< 0.01$) between gluten free flour bread (control) and fortified bread

with 10%, 20% (beans and lentil) powders in overall acceptability, the lowest score of all studied sensory characteristics was recorded for 20% toast bread fortified with beans powder. Such data is in good agreement with **(El-Dreny and El-Hadidy 2020)** reported that the control bread was found to have higher overall acceptability values than bread with bean powder.

Sensory evaluation of gluten-free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders

Sensory evaluation of gluten-free flour crackers and fortified crackers with 10% and 20% (beans and lentil) powders are presented in **Table (10) and Figures (2A-E).** The data in **Table (10)** revealed that there was a statistically highly significant difference at ($p< 0.05$) and ($p< 0.01$) gluten-free flour crackers (control) and fortified crackers with 10%, 20% (beans and lentil) powders in all sensory attributes and overall acceptability, the lowest score of all studied sensory characteristics was recorded for 20% fortified crackers with beans powder. Such data are in good agreement with **(Millar *et al.*, 2017)** who reported that the control crackers were found to have higher overall acceptability values than bread with beans powder, and significant differences existed between the control crackers and the crackers with raw beans powder.

Figure (1A-E): Samples of toast bread

A: Control toast bread
(100% gluten free flour)

B: Toast bread with 10% beans powder

C: Toast bread with 20% beans powder

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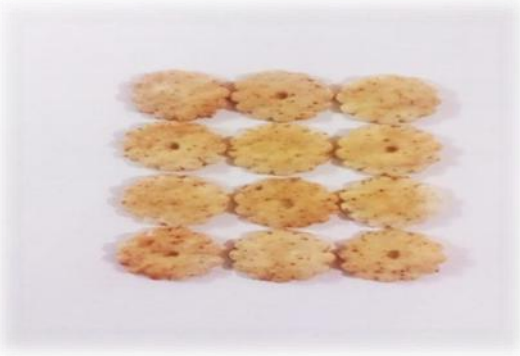
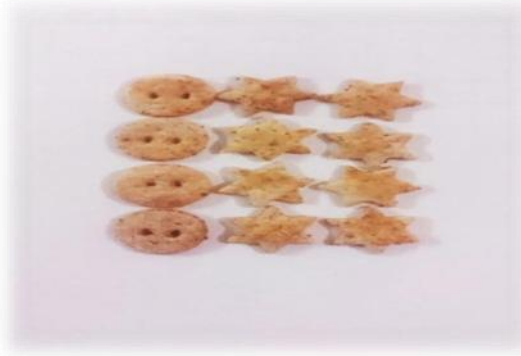
D: Toast bread with 10% lentil powder

F: Toast bread with 20% lentil powder

Figure (2A-E): Samples of crackers

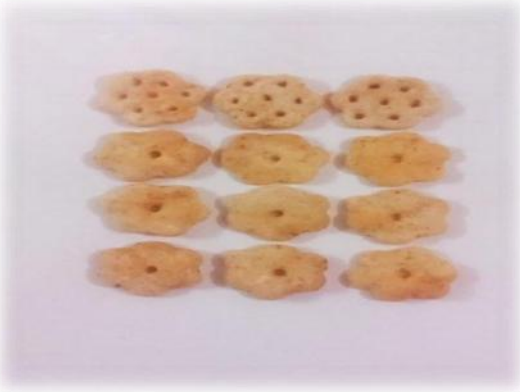
A: Control crackers
(100% gluten free flour)

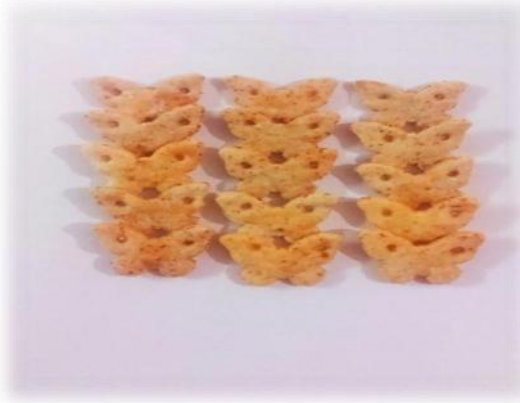




B: Crackers with 10% beans powder

C: Crackers with 20% beans powder





D: Crackers with 10% lentil powder **E:** Crackers with 20% lentil powder

Table (3): Statistical analysis of gross chemical composition and caloric value of gluten-free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders on (W.W)[a] and (D.W)[b] (g/100g).

Samples %	Moisture (g)	Ash (g)	Protein (g)		Crude fiber (g)		Crude fat (g)		Total Carbohydrates (g)		Caloric value (K.cal/100)	
			W.W	D.W	W.W	D.W	W.W	D.W	W.W	D.W	W.W	D.W
Gluten-free toast bread (control)	42.22^{C} ±1.1	1.4^{BC} ±0.1	7.41^{C} ±0.9	12.83^{C} ±1.4	0.37^{E} ±0.01	0.64^{E} ±0.02	5.38^{B} ±0.4	9.31^{B} ±1.2	43.22^{B} ±2.1	75.82^{A} ±3.2	250.94^{B} ±3.2	438.39 ±4.6
Toast bread with 10% beans powder	47.12^{A} ±1.3	1.3^{C} ±0.07	8.82^{B} ±1.1	16.68^{B} ±1.5	0.95^{B} ±0.03	1.79^{B} ±0.04	3.98^{C} ±0.3	7.53^{C} ±0.9	37.83^{D} ±1.7	72.70^{B} ±1.8	222.42^{D} ±4.6	425.29 ±6.7
Toast bread with 20% beans powder	35.37^{D} ±0.9	2.0^{A} ±0.08	10.48^{A} ±1.4	16.22^{B} ±1.3	1.47^{A} ±0.05	2.27^{A} ±0.07	4.30^{C} ±0.4	6.65^{D} ±0.8	46.38^{A} ±1.3	72.86^{B} ±2.4	266.14^{A} ±5.2	416.17 ±5.6
Toast bread with 10% lentil powder	44.54^{B} ±0.8	1.6^{B} ±0.04	9.04^{B} ±0.8	16.30^{B} ±1.7	0.52^{D} ±0.01	0.94^{D} ±0.03	5.91^{A} ±0.3	10.66^{A} ±1.3	38.39^{C} ±1.5	70.50^{C} ±2.6	242.91^{C} ±4.7	443.14 ±6.2
Toast bread with 20% lentil powder	43.39^{BC} ±1.2	1.7^{B} ±0.06	10.36^{A} ±1.3	18.30^{A} ±1.9	0.72^{C} ±0.03	1.27^{C} ±0.05	5.14^{B} ±0.7	9.08^{B} ±0.7	38.69^{C} ±1.3	69.65^{D} ±1.9	242.46^{C} ±3.8	433.52 ±7.1
F-test	71.15 *	38.87* *	20.00 **	7.41 *	20.1 **	18.9 **	19.37 **	28.98 **	6.77 *	9.87 **	12.32 **	43.15 **

- Mean of three replicates. * Significant ($P < 0.05$). ** High significant ($P < 0.01$).
-Total carbohydrates were calculated by difference.
a:(W.W)= wet weight basis. **b:(D.W)**= dry weight basis.
*A, B, C, D, E superscripts letters indicate significant differences among groups in the same column.

Table (4): Statistical analysis of gross chemical composition and caloric value of gluten-free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders on (W.W)[a] and (D.W)[b] (g/100g).

Samples %	Moisture (g)	Ash (g)	Protein (g)		Crude fiber (g)		Crude fat (g)		Total Carbohydrates (g)		Caloric value (K.cal/100)	
			W.W	D.W	W.W	D.W	W.W	D.W	W.W	D.W	W.W	D.W
Gluten-free crackers (control)	9.49^{A} ±0.7	1.9^{B} ±0.1	7.88^{B} ±1.2	8.71^{C} ±0.5	0.99^{C} ±0.02	1.09^{C} ±0.01	0.43^{D} ±0.01	0.48^{D} ±0.02	79.31^{B} ±2.1	87.82^{A} ±1.6	352.63^{C} ±3.4	390.4 ±4.1
Crackers with 10% beans powder	3.68^{B} ±0.3	1.8^{B} ±0.2	8.26^{B} ±0.8	8.58^{C} ±0.2	1.20^{B} ±0.04	1.25^{B} ±0.03	7.08^{A} ±0.5	7.35^{A} ±0.7	77.98^{B} ±3.6	81.02^{B} ±2.3	408.68^{B} ±2.7	424.5 ±5.6
Crackers with 20% beans powder	3.57^{B} ±0.2	1.2^{C} ±0.04	9.11^{AB} ±0.9	9.45^{B} ±0.3	1.44^{A} ±0.03	1.49^{A} ±0.02	6.13^{B} ±0.7	6.36^{B} ±0.6	78.55^{B} ±4.1	81.50^{B} ±2.7	405.81^{B} ±5.6	421.0 ±7.2
Crackers with 10% lentil powder	1.92^{C} ±0.1	1.0^{C} ±0.06	7.53^{C} ±1.3	7.68^{D} ±0.5	0.77^{D} ±0.01	0.79^{D} ±0.01	5.53^{C} ±0.6	5.64^{C} ±0.7	83.25^{A} ±2.4	84.89^{AB} ±2.0	412.89^{A} ±2.6	421.0 ±6.5
Crackers with 20% lentil powder	1.62^{D} ±0.06	2.3^{A} ±0.2	10.00^{A} ±0.7	10.16^{A} ±0.6	1.14^{B} ±0.02	1.16^{B} ±0.02	7.12^{A} ±0.6	7.24^{A} ±0.8	77.82^{B} ±1.6	79.14^{B} ±1.6	415.36^{A} ±3.7	422.3 ±3.4
F-test	23.15 **	11.25 **	8.35 **	9.12 **	11.12 **	13.10 **	17.12 **	16.21 **	2.15 N.S	5.12 *	9.85 **	1.96 N.S

- Mean of three replicates. * Significant ($P < 0.05$). ** High significant ($P < 0.01$).

N.S (The difference non- significant). -Total carbohydrates were calculated by difference.

a:(W.W)= wet weight basis. **b:(D.W)**= dry weight basis.

*A, B, C, D, E superscripts letters indicate significant differences among groups in the same column.

Table (5): Statistical analysis of minerals content of gluten-free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders (mg/100g)

Samples %	P (mg)	Fe (mg)	Mg (mg)
Gluten-free toast bread (control)	120.42^{C} ±2.3	15.21^{C} ±1.1	55.10^{B} ±2.1
Toast bread with 10% beans powder	129.96^{B} ±3.4	21.25^{B} ±1.3	50.88^{C} ±3.1
Toast bread with 20% beans powder	145.52^{A} ±4.6	23.14^{B} ±1.7	63.26^{A} ±2.6
Toast bread with 10% lentil powder	126.62^{B} ±3.8	24.16^{B} ±2.1	45.77^{D} ±1.5
Toast bread with 20% lentil powder	143.76^{A} ±4.8	30.38^{A} ±1.6	43.45^{D} ±1.3
F-test	11.36**	5.23*	13.25**

- Mean of three replicates. * Significant ($P < 0.05$). ** High significant ($P < 0.01$).

*A, B, C, D, E superscripts letters indicate significant differences among groups in the same column.

Table (6): Statistical analysis of minerals content of gluten-free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders (mg/100g)

Samples %	P (mg)	Fe (mg)	Mg (mg)
Gluten-free crackers (control)	169.74^{C} ±3.6	28.59^{B} ±0.8	123.62^{A} ±2.3
Crackers with 10% beans powder	176.57^{B} ±2.7	34.24^{A} ±0.6	126.92^{A} ±1.2
Crackers with 20% beans powder	180.85^{B} ±3.4	32.86^{A} ±1.2	107.41^{B} ±1.6
Crackers with 10% lentil powder	126.48^{D} ±1.8	16.93^{D} ±1.4	52.07^{D} ±0.9
Crackers with 20% lentil powder	187.51^{A} ±2.3	22.17^{C} ±0.6	90.40^{C} ±2.3
F-test	13.26**	11.62**	14.25**

- Mean of three replicates. * Significant (P < 0.01).

*A, B, C, D, E superscripts letters indicate significant differences among groups in the same column.

Table (7): Statistical analysis of the physical characteristics of gluten- free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders

Physical characteristics / Samples	Weight (g)	Volume (ml)	S.L.V
Gluten-free toast bread (control)	147^{D}±2.3	366^{E}±4.5	2.5^{A}±0.01
Toast bread with 10% beans powder	168^{C}±1.7	419^{B}±6.2	2.5^{A}±0.02
Toast bread with 20% beans powder	181^{A}±2.2	427^{A}±3.4	2.4^{A}±0.01
Toast bread with 10% lentil powder	150^{D}±1.4	392^{C}±4.2	2.6^{A}±0.02
Toast bread with 20% lentil powder	175^{B}±1.6	383^{D}±3.5	2.2^{B}±0.02
F-test	41.23**	25.16**	N.S

- Mean of three replicates. ** High significant (P < 0.01). N.S(The difference non-significant).

*A, B, C, D, E superscripts letters indicate significant differences among groups in the same column.

Table (8): Statistical analysis of physical characteristics of gluten- free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders

Physical characteristics / Samples	Width Cm	Thickness Cm (a)	Spread ratio (b)	Spread factor% (c)
Gluten-free Crackers (control)	5.70^{B} ±0.8	0.70^{B} ±0.01	8.14^{A} ±0.5	100^{A} ±2.4
Crackers with 10% beans powder	5.75^{B} ±1.3	0.70^{B} ±0.03	8.21^{A} ±0.3	100.86^{A} ±2.6
Crackers with 20% beans powder	5.95^{A} ±0.9	0.80^{A} ±0.02	7.44^{B} ±0.4	91.40^{B} ±2.7
Crackers with 10% lentil powder	5.90^{A} ±0.7	0.70^{B} ±0.04	8.43^{A} ±0.6	103.56^{A} ±2.9
Crackers with 20% lentil powder	5.80^{B} ±0.6	0.70^{B} ±0.03	8.29^{A} ±0.7	101.84^{A} ±3.2
F-test	1.85N.S	1.63N.S	2.12N.S	1.96N.S

- Mean of three replicates. N.S(The difference non- significant).

Width Spread ratio of sample

a= Thickness of 3 crackers in series. b= ——————— X100 c = ———————

Height Spread ratio of control

*A, B, C, D, E superscripts letters indicate significant differences among groups in the same column.

Table (9): Statistical analysis of sensory evaluation of gluten-free flour toast bread and fortified toast bread with 10%, 20% (beans and lentil) powders

Sensory Evaluation	Crust colour	Crumb colour	Graining	Texture	Taste	Odor	Over all acceptability
Samples	10	10	10	10	10	10	10
Gluten-free toast bread (control)	8.5^{A} ±0.1	8.0^{B} ±0.3	8.3^{A} ±0.1	7.9^{A} ±0.4	8.2^{A} ±0.2	8.3^{A} ±0.1	8.4^{A} ±0.3
Toast bread with 10% beans powder	$8.4A^{B}$ ±0.2	8.0^{B} ±0.1	7.7^{B} ±0.3	8.1^{A} ±0.2	7.8^{B} ±0.3	7.7^{B} ±0.2	7.8^{B} ±0.2
Toast bread with 20% beans powder	8.3^{AB} ±0.3	7.4^{C} ±0.2	7.5^{B} ±0.2	7.7^{AB} ±0.3	7.3^{C} ±0.4	7.5^{B} ±0.3	7.1^{C} ±0.4
Toast bread with 10% lentil powder	7.7^{B} ±0.1	7.8^{B} ±0.2	8.2^{A} ±0.4	7.8^{AB} ±0.1	7.6^{B} ±0.1	7.8^{B} ±0.2	7.6^{B} ±0.1
Toast bread with 20% lentil powder	8.7^{A} ±0.2	8.7^{A} ±0.3	8.4^{A} ±0.1	8.1^{A} ±0.2	7.8^{B} ±0.2	7.7^{B} ±0.1	8.0^{B} ±0.3
F-test	4.05*	4.23*	N.S	N.S	8.6**	4.12*	11.25**

- Mean of three replicates. N.S(The difference non-significant).

* Significant ($P < 0.05$). ** High significant ($P < 0.01$).

*A, B, C, D, E superscripts letters indicate significant differences among groups in the same column.

Sensory Evaluation	Taste	Colour	Texture	Over all accept ability
Samples	**10**	**10**	**10**	**10**
Gluten-free Crackers (control)	8.6^{A} ±0.6	8.4^{A}±0.8	8.4^{A}±0.8	8.3^{A}±0.6
Crackers with 10% beans powder	8.0^{AB}±0.8	7.8^{B}±0.6	7.9^{B}±0.7	7.9^{B}±0.8
Crackers with 20% beans powder	7.4^{B}±1.1	7.2^{C}±0.3	7.3^{C}±0.9	7.2^{C}±0.5
Crackers with 10% lentil powder	7.9^{AB}±0.9	7.7^{B}±0.4	7.8^{B}±0.3	7.7^{B}±0.7
Crackers with 20% lentil powder	8.2^{A}±0.6	8.0^{AB}±0.5	8.3^{A}±0.5	8.1^{A}±0.4
F-test	4.12*	3.96*	7.25**	8.12**

Table (10): Statistical analysis of sensory evaluation of gluten- free flour crackers and fortified crackers with 10%, 20% (beans and lentil) powders

- Mean of three replicates. * Significant ($P < 0.05$). ** High significant ($P < 0.01$).
*A, B, C, D, E superscripts letters indicate significant differences among groups in the same column.

Conclusion

In Conclusion, this study demonstrates that the chemical composition of toast bread and crackers is fortified with natural sources of protein. The chemical composition of toast bread was fortified with 20% lentil powder recorded with the highest values of protein and toast bread was fortified with 20% beans powder recorded with the highest values of ash and crude fiber. While, toast bread fortified with 20% beans powder had the highest phosphorous and magnesium values (145.52 mg/kg and 63.26 mg/kg); respectively, toast bread fortified with 20% lentil powder had the highest iron value (30.38mg/kg). Also, the chemical composition of crackers was fortified with 20% lentil powder recorded with the highest values of protein and ash and crackers were fortified with 20% beans powder were recorded with the highest values of crude fiber. While, crackers fortified with 10% bean powder had the highest iron and magnesium values (34.24mg/kg and 126.92mg/kg);

respectively, crackers fortified with 20% lentil powder had the highest phosphorous value (187.51mg/kg). Based on the sensory characterizes of toast bread and crackers fortified with 20% lentil powder was the best acceptable to the panelists. So (beans and lentils) powder could be useful in different food formulations.

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التركيب الكيميائي والقيمة الغذائية لبعض المنتجات الخالية من الجلوتين والمدعمة ببعض البقوليات

الملخص

هدفت الدراسة الحالية إلى تقدير التركيب الكيميائي والقيمة الغذائية لخبز التوست والمقرمشات المدعمة بنسبة ١٠٪ و٢٠٪ من مساحيق (الفول والعدس) كمصدر طبيعي للبروتين. علاوةً علي التقييم الفيزيائي والحسي لخبز التوست والمقرمشات. أظهرت نتائج البروتين والألياف والكربوهيدرات الكلية لخبز التوست المدعم بنسبة ١٠٪ و٢٠٪ من مساحيق (الفول والعدس) ارتفاعاً معنوياً عند مستوي ($P< 0.01$) مقارنةً بالكنترول ،التي سجلت (١٨,٣٠٪ ، ٢,٢٧٪ ، ٧٢,٨٦٪) في خبز التوست المدعم بنسبة ٢٠٪ من مساحيق الفول والعدس عل التوالي. بينما أظهر التحليل الإحصائي لقيم الرماد والدهون الخام والسعرات الحرارية ارتفاعاً بين جميع عينات خبز التوست عند مستوي ($P< 0.01$). بينما أظهرت النتائج ارتفاعاً معنوياً في الفوسفور والحديد لخبز التوست المدعم بنسبة ١٠% و٢٠% من مساحيق (الفول والعدس) مقارنةً بالكنترول.

كما أظهرت نتائج البروتين والألياف والكربوهيدرات الكلية للمقرمشات المدعمة بنسبة ١٠٪ و٢٠٪ من مساحيق (الفول والعدس) ارتفاعاً معنوياً عند مستوي ($P< 0.05$) مقارنةً بالكنترول ،التي سجلت (١٠,١٦٪ ، ١,٤٩٪ ، ٨٤,٨٩٪) في المقرمشات المدعمة بنسبة ٢٠٪ من مساحيق العدس والفول و١٠٪ من مسحوق العدس علي التوالي. بينما أظهر التحليل الإحصائي لقيم الرماد والدهون الخام والسعرات الحرارية ارتفاعاً بين جميع عينات المقرمشات عند مستوي ($P< 0.01$). بينما أظهرت النتائج ارتفاعاً معنوياً في الفوسفور والحديد والماغنيسيوم للمقرمشات المدعمة بنسبة ١٠٪ من مسحوق الفول مقارنةً بالكنترول. أيضاً أظهرت النتائج أن أعلي درجة من التقبل العام كانت في خبز التوست والمقرمشات المدعمة بنسبة ٢٠٪ من مسحوق العدس. لذلك يمكن التوصية باستخدام (الفول والعدس) في المنتجات الغذائية كغذاء وظيفي وإثراء النظم الغذائية من أجل الاستفادة بشكل أفضل من البروتين.

الكلمات المفتاحية

التركيب الكيميائي ، العناصر المعدنية ، الفول ، العدس ، الخبز ، المقرمشات.