Nutritional Value and Chemical Composition of Bread Fortified with Natural Sources of Iron and Calcium

القيمة الغذائية والتركيب الكيميائي للخبز المدعم بمصادر طبيعية من الحديد والكالسيوم

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Abstract

The current study aimed to evaluate the nutritional value and chemical composition of bread fortified with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder as a natural source of iron and calcium. Likewise, the physical properties and sensory characteristics of the studied bread were assessed. The results showed that protein, crude fiber and carbohydrates values in bread fortified with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder were high significantly than the control at ($p < 0.05$), while the statistical analysis showed that the values of ash, crude fat and calories value in (W.W) were highly significant between in all studied bread and control bread at ($p < 0.01$). On the other hand, results revealed that moisture content in all studied bread and control bread not statistically difference. Iron and calcium content of (flax seed, chia seeds, wheat germ and moringa powder) fortified bread were significantly higher than the control bread. The highest value of iron content of bread fortified with 10% flax seeds was (33.81mg/100g) and the highest value of calcium content of bread fortified with 10% chia seeds was (242.20 mg/100g) compared with all samples. Likewise, bread made by fortification with 10%wheat germwas recorded the highest overall acceptability, while bread fortified with 5% moringa powder was recorded the lowest overall acceptability. So the use of (flax seeds, chia seeds and wheat germ) in dietary products can be recommended as functional.

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food and enrichment of diets for better utilization of iron and calcium

Keywords: chemical composition, mineral content, flax seeds, chia seeds, wheat germ, moringa powder, bread.

Introduction

Grains have represented the principal component of the human diet for thousands of years. Since cereals are an important source of carbohydrates, proteins, lipids, vitamins, mainly of B-complex and vitamin E, magnesium and zinc and inorganic and trace elements, the reutilization and valorisation of their by-products is a great challenge toward the sustainable development of the agro-food sector *Poole et al., (2020)*.

Bread takes a leading place in the diet of all socio-demographic groups of the population *Ermosh et al., (2020)*.With the increasing awareness of the consumption of healthy food, the production of bread from whole wheat flour is highly recommended in the bakery industry. Whole wheat flour led to improvement of the nutritional values and fiber content of the final bread, while the aesthetic value and the sensory properties are negatively affected by comparison with bread made from white flour *Bouchra et al., (2018)*.

Flax seeds*(Linum usitatissimum L.)*plant of the family Linaceae, one of the oldest cultivated crops, continues to be widely grown for oil, fiber, and food *Oomah, (2001)*. Flaxseeds have a hard shell that is smooth and shiny and the color ranges from deep amber to reddish brown depending upon whether the flax is of the golden or brown variety *Daun et al., (2003)*.

Chia seeds *(Salvia hispanica L)*species of flowering plant in the mint family (Lamiaceae) are an excellent source of fat, particularly polyunsaturated fatty acids. Moreover, high levels of protein, and fibre contents, Vitamins (mostly B complex) and minerals (calcium, phosphorus, and potassium). Chia seeds are also a source of antioxidants due to their described composition, the flowers are purple or white and sized 3-4 mm, which is about 2 mm long, the seeds are mottle -coloured with brown, grey, black and white *Mohd et al., (2012)*.chia seeds have been related to different medicinal effects, particularly anti-inflammatory and anti-diabetic activities and positive effects on cardiovascular disease and hypertension *Melo et al., (2019)*.

Wheat germ (WG) ***(Triticum)*** **is a by-product of the flour milling industry. The germ is the most valuable part of the wheat and it represents about 2.5 % of the weight and an important in the food processing of high nutrition value. It is a high source of vitamins, minerals, fiber and proteins. WG is rich in tocopherols and B complex vitamins, protein containsa high average of amino acids, especially the essential amino acids lysine, methionine and threonine and helps to prevent heart diseases, cancers and diabetes** ***Nagib, (2018).***

Miracle tree ***(Moringa oleifera)*** **as it is popularly called, has been found useful both medicinally and economically. Moringa oleifera is the most widely cultivated species of the monogeneric family, the moringaceae, moringa oleifera.** ***Sharma et al., (2011)*****. It is one of the richest plant sources of vitamins A, B, C, D, E and K. The vital minerals present in moringa include calcium, copper, iron, potassium, magnesium, manganese and zinc; it has more than 40 natural anti-oxidants; support a healthy cardiovascular system, promote normal blood-glucose levels, neutralize free radicals, provide excellent support of the body's anti-inflammatory mechanisms, enrich anaemic blood and support the immune system. It also improves eyesight, mental alertness and bone strength. It has potential benefits in malnutrition, general weakness, lactating mothers, menopause, depression and therapeutic use osteoporosis** ***Khawaja et al., (2010).***

Micronutrients are essential elements required by humans and other organisms in varying quantities throughout life to coordinate a range of physiological functions for health maintenance. For human nutrition, micronutrients are required in amounts generally below 100 milligrams per day, while macronutrients are required in gram amounts daily , and the major minerals (macro minerals) and minor minerals (trace elements) 4% of the weight of the human body. The five major minerals in the human body are calcium, phosphorus, potassium, sodium, and magnesium (macro minerals or macroelements). The trace elements with specific biochemical functions in the human body are iodine, sulfur, zinc, iron, chlorine, cobalt, copper, manganese, molybdenum, and selenium***Godswill et al., (2020).***

The objective of this study was to determine the nutritional value and chemical composition of bread fortified with natural sources of iron and calcium.

• Materials and Methods

Materials

Source of Samples

Flax seeds*(Linum usitatissimum L.)*, chia seeds*(Salvia hispanica L)*, wheat germ *(Triticum)* and moringa *(Moringa oleifera)*were obtained from Agriculture Research Center, Giza, Cairo, Egypt.

Wheat flour 72% extraction (El-Salam), salt (sodium chloride) and dry yeast were purchased from Assiut local markets.

Preparation of Samples

- **Flax seeds, chia seeds, wheat germ and moringa were cleaned from foreign objects and dirt materials then grinding wheat germ and moringa (Molunix, Al – Araby Company, Banha, Egypt) were electrical to pass through a sieve. Samples were stored in polyethylene bags at 4ºc in the refrigerator until use.**

• Technological process

Bread formula and ingredients

Control bread dough was prepared according to the formula presented in according to *Rossi et al., (2020)*table (1). The fortified bread with (flax seeds, chia seeds, wheat germ and moringa powder) were prepared using the same formula except for adding 10% of (flax seeds, chia seeds, wheat germ) and 5% moringa powder.

Table (1): Bread Formula*

Ingredients	Quantity (g)
Wheat flour (72% extraction) (g)	100
Sodium chloride (g)	1
Dry Yeast (g)	0.5
Water (ml)	60

*** *Rossi et al., (2020)*.**

Dough preparation

Wheat flour, water, salt (sodium chloride), yeast and (flax seeds, chia seeds, wheat germ and moringa powder)were added on the expense of wheat flour using the proportions given in Table (1) were mixed in the kneader dough for 10 minutes. C ±2 for 135 minutes and ºFermentation was performed at 30 relative humidity 80-85 %.

Preparation of bread

The dough is pressed to release CO_2 and molded with corn oil (about 1.5 g oil) in pans with dimensions: length 12cm, width 6cm and height 8cm. baking was carried out in an C for 20 – 25 minutes. The bread top ºelectric oven at 230 – 240 was subjected to a wet brush in order to enhance crust appearance immediately after removing from the oven *Rossi et al., (2020)*.

The bread samples were executed as follow:

- **Sample (1): The control sample has been using 100% of wheat flour, (extraction 72%).**
- **Sample (2): Bread fortified with 10% flax seeds.**
- **Sample (3): Bread fortified with 10% chia seeds.**
- **Sample (4): Bread fortified with 10% wheat germ.**
- **Sample (5): Bread fortified with 5% moringa powder.**

Methods

Determination of chemical composition

Moisture, protein, crude fat, crude fiber and ash contents, were determined by the Soxhlet apparatus according to the method described by *A.O.A.C., (2010)*. The caloric value was calculated according to the method of *Seleet, (2010)*.

4 + total ×9 + protein × Total calories = fat
4. ×carbohydrates

Determination of mineral contents

The total content of elements was carried out using a mixture of perchloric acid / nitric acids ($HClO_4$ / HNO_3) according to (Inductively Coupled Plasma Emission Spectrometry) the **elements, Iron (Fe) and Calcium (Ca) were determined using the ICP (ICAP 6200) according to *Isaac and Johnson, (2002)*.**

Physical evaluation of bread

Loaves were weighed in grams after two hours from baking and the volume in (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 *Rossi et al., (2020)*using the following equation:

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

Sensory evaluation of bread

Sensory evaluation for the color (crust and crumb), graining, texture, taste, odor and overall acceptability were done in order to determine consumer acceptability. A numerical hedonic scale ranging from 1 to 10 (1 is very bad and 10 for excellent) was used for sensory evaluation *Mostafa and Othman, (1986)*. Ten experienced judges from the staff of Nutrition and Food Science Department, Faculty of Specific Education, Assiut University, Egypt and fifteen consumers.

Statistical Analysis of bread

The data were subjected to statistical analysis of variance and treatment means were compared for significant differences using Duncan's Multiple Range Test significant differences at P 0.05 according to the MSTAT-C Statistical software *Russell,* < *(1993)*. A computer program was used to perform all the analysis of variance in agreement with the procedure outlined by *Duncan, (1995)*.

Results and Discussion

The data in Table (2) revealed a significant variation at (P< 0.05) in moisture and ash content in bread fortified with (flax seeds, chia seeds, wheat germ and moringa powder) when compared with wheat bread 72% extraction (control). Results indicated that wheat flour bread and fortified bread with natural sources in protein were ranged from 14.04% to 20.09% on a dry weight basis (D.W) and 9.40% to 13.36% on a wet weight basis (W.W). On the other hand, crude fiber and crude fat were recorded a high values (4.22% - 16.08%) in (D.W) and (2.92% - 11.44%) in (W.W); respectively in bread fortified with 10% chia seeds and 10% flax seeds. Total carbohydrates were recorded a highly values (69.59% and 45.65%) in bread fortified with 10% wheat germ on (D.W) and (W.W) while, the

caloric value was recorded high values in bread fortified with 10% flax seeds (463.52-327.52) K.cal/100g. Our results are in agreement with *Hussain et al., (2011)* who reported thatflax seed flours supplemented wheat flour significantly improved the chemical composition (crude fat, crude fiber and crude protein) and *Mansour et al., (2018)* who showed that fortification of wheat flour with full flax seed flour and defatted flax seed flour up to 15% increased the crude protein from 12.05 to 14.47%, crude fiber from 0.37 to 1.38% and ash from 3.64 to 5.54%. While, caloric values of the obtained bread were decreased. The increase in protein, ash and fiber contents in pan bread samples were due to their higher contents in full flax seed flour and defatted flax seed flour than in flour. The decrease in carbohydrates and caloric value in pan bread samples was due to the highest fiber contents in full flax seed flour and defatted flax seed flour. On the other hand,*Romankiewicz et al., (2017)* who reported that the changes in the chemical composition of bread fortified with chia seeds showed that the addition of 8% chia seeds to wheat flour significantly increased the total protein content from (10.82 %) to (11.96 %), total fat content from (1.12 %) to (2.53 %), total ash content from (0.95 %) to (1.34%) and total dietary fiber content from (3.58%) to (7.19%).While, moisture content decreased from (43.83%) to (43.52%) due to the addition of 8% of (chia seeds) significantly reduced the value of the baking loss as compared to other breads. chia seeds contain a lot of dietary fiber and mucilage, which combines free water and prevents its evaporation during the process of baking. Also,*Gnanavinthan et al., (2010)* stated that although chia seeds have high protein content, it cannot form a continuous gluten-like network, thus impairing water entrapment. Additionally, proteins compete with starch for water, delaying starch swelling and gelatinization. It can be concluded that the method of bread dough preparation, especially involving raw gluten-free and high-fibre content, can be very important for loaf volume, baking loss, or bread crumb moisture content. And *Abd El-Hafez, (2013) & Noori and Sabir, (2019)* showed that the amount of fat, protein, and ash increases with the increase in the rate of wheat germ addition; when adding 10% wheat germ to bread led to increased fat content from (2.26%) to (2.81%), protein content from (13.66%) to (14.52%) and ash content from (1.73%) to (3.13%). This conceivably is due to the

wheat germ adding that is rich in fat, protein, and ash content which increase the viscosity of the paste and this may lead to competing on water content between all wheat and germ component that leads to rising the viscosity pick faster than the control and this leads to lower the gelatinization temperature, while the rate of carbohydrate decreased from (72.6%) to (69.52%); moisture content was decreased also due to wheat germ contains a lower moisture content compared to the moisture content of wheat flour, as the moisture content of wheat germ is (12.3%), while the moisture content of wheat flour is (13.8%). It is noticed that *Sengev et al., (2013); El-Gammal et al., (2016) & Govender and Siwela, (2020)* found that increasing amount of moringa leaves powder to pan bread raised the amount of total fat and ash in all pan bread as compared with control sample due to moringa oleifera leaves were as a good source of fat, ash and crude fiber compared with these compounds in wheat flour. Variations in moisture contents, ash, protein, crude fiber, crude fat and carbohydrates due to several factors can affect these compositions such as cultivar, growing and postharvest management and processing conditions.

The data tabulated that the minerals content of wheat flour bread and fortified bread with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powderin Table (3) recorded highly significant differences at (p < 0.01) between control bread and fortified bread in Ca and Fe contents. The data in Table (3) recorded that the highest values of iron (33.81%) in bread fortified with 10% flax seeds. While, in bread fortified with 10% chia seeds were recorded (242.20%) in calcium. On the other hand, calcium and iron were recorded the lowest values (104.90% and 30.75%) in bread fortified with 10% wheat germ; respectively. These results are in agreement with those of *Belc et al., (2020)* who found that bread supplemented with 10% partially defatted flax seed flour led to an increase in calcium and iron content, as the content of calcium (45.78 mg/100g) and iron (13.73 mg/100g) compared to the control sample that had calcium (41.50 mg/100g) and iron (4.78 mg/100g)due to partially defatted flax seed flour contains a higher value of calcium and iron compared to wheat flour. Also,*Chelladurai et al., (2019)* mentioned that the content of iron and calcium in cookies fortified with 10% chia seeds was increased compared with wheat flour cookies (control) due to

chia seeds having a high amount of calcium and medium value in iron. And *Barrientos et al., (2012)* showed that the addition of chia to cookies did significantly increase the contents of calcium. Cookies supplemented with chia (10%) had 1.87 times more calcium than the control. On the other hand,*Youssef, (2015)* obtained that the content of iron and calcium in biscuits fortified with 15% wheat germ flour were increased due to a higher Fe and Ca content of wheat germ than wheat flour. It is noticed that *El-Gammal et al., (2016)* reported that the content of iron was (10.51mg/100g) and calcium (189.50 mg/100g) in bread substituted with 5% moringa leaves powder due to moringa leaves powder is considered as a rich source of Ca and Fe. While, *Gernah and Sengev, (2011)* detected that the content of iron and calcium recorded 26.20, 454 mg/100 g, respectively in moringa leaf powder.

The statistical analysis of physical characteristics of wheat flour bread and fortified bread with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powderin Table (4). The data in Table (4) outlined that significant differences between weight (g) and volume (ml) of bread fortified with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder. The data showed that the highest value of weight and volume in bread fortified with 10% flax seeds were (152.50 g and 180 ml) when compared with other treatments. On the other hand bread fortified with 5% moringa recorded the lowest value of volume (150.00 ml).These results in agreement with *Mansour et al., (2018)* who mentioned that loaf volume and specific volume were decreased in all samples compared to the control and weight increased in all samples compared to the control. A similar effect was observed with bread density while, the decrease in specific volume may be due to the lower gluten content in the flax seed bread. Lower specific volume values of bread with the addition or partial replacement of wheat flour with non-glutinous flour may be due to the lower gluten in the additives which gives a less active gluten network and gas trapping and that might be strongly related to higher bread hardness. Also,*Adamczyk et al., (2021)* found that bread volume reduced with increased addition of chia seeds to bread due to the formation of a protein–lipid complex that hinders the formation and retention of gas, the reduction in bread volume may be due to the introduction of fiber-rich products into the system. The presence of fiber in the dough negatively affects

the formation and properties of gluten, and this reduces its ability to retain gases. While, *Noori and sabir, (2019)* detected that indicated the negative effect of staling on the volume of the loaf with wheat germ; this might be due to the limited aging of the separated wheat germ at ambient temperature, a problem which has been an obstacle to its applications in many food products. And *Sengev et al., (2021)* reported that the addition of moringa increased the weight of the loaves, resulting in a decrease in the height and volume of the bread. The increase in bulk and closure of air spaces necessary for rising may have occurred as moringa was introduced into the composite. The decrease in height and volume may also be due to the antimicrobial action of moringa oleifera leaves on the leavening activities of yeast during fermentation of the dough.

Statistical analysis of sensory characteristics of wheat flour bread and fortified bread with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder are presented in Table (5). The data in Table (5) revealed that there was a highly significant difference at ($P < 0.01$) between wheat flour bread (control) and fortified bread with (flax seeds, chia seeds, wheat germ and moringa powder) in all sensory attributes and overall acceptability, the lowest scores were recorded for 5% moringa powder fortified bread. The best score of all studied sensory characteristics was recorded for 10% fortified bread with wheat germ, flax seeds and chia seeds. Such data are in good agreement with *Gómez et al., (2012)* who reported that the control bread was found to have higher overall acceptability values than bread with wheat germ, and significant differences existed between the control bread and the bread with raw wheat germ.

Table (2): Statistical analysis of gross chemical composition of wheat flour bread and fortified bread with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder on (D.W)[a] and (W.W)[b] (g/100g)*

Samples %	Moisture (g)	Ash (g)	Protein (g)		Crude fiber (g)		Crude fat (g)		Total carbohydrates (g)		Caloric value (K.cal/100g)	
			D.W	W.W	D.W	W.W	D.W	W.W	D.W	W.W	D.W	W.W
Wheat bread 72% extraction (control)	33.60^{A} ±0.6	0.59^{D} ±0.01	14.04^{C} ±0.8	9.40^{C} ±0.7	1.23^{C} ±0.02	0.82^{C} ±0.01	2.99^{E} ±0.1	2.00^{E} ±0.3	81.15^{A}±1 .35	53.59^{A} ±0.9	407.67^{D} ±4.5	270.00^{E} ±2.3
Bread with 10% flax seeds	28.83^{B} ±0.5	2.03^{B} ±0.02	18.06^{B} ±0.9	12.85^{A} ±0.3	2.19^{B} ±0.03	1.56^{B} ±0.01	16.08^{A} ±0.5	11.44^{A} ±0.4	61.64^{C}±1 .30	43.29^{B} ±1.2	463.52^{A} ±5.9	327.52^{A} ±4.5
Bread with 10% chia seeds	30.82^{B} ±0.4	1.81^{C} ±0.01	17.12^{B} ±0.8	11.84^{B} ±0.7	4.22^{A} ±0.1	2.92^{A} ±0.2	13.18^{B} ±0.3	9.12^{B} ±0.3	63.67^{C}±2 .01	43.49^{B} ±1.3	441.78^{B} ±6.3	303.40^{B} ±5.2
Bread with 10% wheat germ	33.49^{A} ±0.8	1.89^{C} ±0.02	20.09^{A} ±0.6	13.36^{A} ±0.6	1.35^{C} ±0.3	0.90^{C} ±0.02	7.08^{D} ±0.3	4.71^{D} ±0.4	69.59^{B}±0 .95	45.65^{B} ±0.8	422.44^{C} ±7.2	278.43^{D} ±2.8
Bread with 5% moringa powder	34.08^{A} ±0.9	2.30^{A} ±0.01	18.57^{B} ±1.1	12.24^{B} ±0.5	1.44^{C} ±0.04	0.95^{C} ±0.01	10.56^{C} ±0.4	6.96^{C} ±0.2	67.13^{B}±1 .65	43.47^{B} ±0.7	437.84^{B} ±8.6	285.50^{C} ±3.1
F-test	1.33 N.S	7.25**	4.22*	9.24**	5.10*	4.33*	10.36**	17.63**	4.34*	1.86 N.S	9.89**	11.36**

*Mean of three replicates.

* Significant ($p < 0.05$). ** High significant ($p < 0.01$). N.S (The difference non-significant).

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

Table (3): Statistical analysis of minerals content of wheat flour bread and fortified bread with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder(mg/100g)*

Samples %	Ca (mg)	Fe (mg)
Wheat bread 72% extraction (control)	53.20^{C}±1.87	21.89^{B}±0.85
Bread with 10% flaxseeds	106.20^{B}±1.86	33.81^{A}±0.24
Bread with 10% chia seeds	242.20^{A}±4.65	31.59^{A}±0.41
Bread with 10% wheat germ	104.90^{B}±2.23	30.75^{A}±0.71
Bread with 5% moringa powder	235.00^{A}±4.26	31.83^{A}±0.35
F-test	41.25**	17.76**

*Mean of three replicates. ** High significant ($p < 0.01$).

Table (4): Statistical analysis of physical characteristicsof wheat bread and fortified bread with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder*

physical characteristics / Samples	Weight (g)	Volume (ml)	S.L.V
Wheat bread 72%extraction(control)	135.00^{B}±2.24	200.0^{A}±4.18	1.48^{A}±0.01
Bread with 10% flaxseeds	152.50^{A}±3.62	180.00^{B}±3.16	1.18^{B}±0.03
Bread with 10% chia seeds	150.00^{A}±3.86	158.00^{C}±1.86	1.05^{C}±0.01
Bread with 10% wheat germ	151.00^{A}±3.29	160.00^{C}±3.55	1.06^{C}±0.02
Bread with 5% moringa powder	151.50^{A}±2.86	150.00^{D}±2.86	0.99^{C}±0.02
F-test	4.16*	12.20**	4.27*

* Significant (p < 0.05). ** High significant (p< 0.01).

Table(5): Statistical analysis of sensory characteristics of wheat flour bread and fortified bread with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder*

sensory characteristics	Crust Color	Crumb Color	Graining	Texture	Taste	Odor	Overall acceptability
Samples	10	10	10	10	10	10	10
Wheat bread 72%extraction(control)	9.68^{A}±0.1	9.52^{A}±0.1	9.48^{A}±0.1	9.40^{A}±0.2	9.72^{A}±0.1	9.72^{A}±0.1	9.64^{A}±0.2
Bread with 10% flaxseeds	9.24^{C}±0.2	9.36^{B}±0.1	9.08^{B}±0.2	9.16^{B}±0.2	9.32^{B}±0.2	9.40^{B}±0.2	9.28^{C}±0.1
Bread with 10% chia seeds	8.92^{D}±0.2	9.12^{C}±0.2	9.08^{B}±0.2	8.84^{C}±0.1	9.28^{B}±0.1	9.04^{C}±0.2	9.08^{D}±0.1
Bread with 10% wheat germ	9.56^{B}±0.1	9.52^{A}±0.1	9.08^{B}±0.2	9.16^{B}±0.1	9.08^{C}±0.2	9.44^{B}±0.2	9.40^{B}±0.1
Bread with 5% moringa powder	7.80^{E}±0.1	7.88^{D}±0.2	8.08^{C}±0.1	8.32^{D}±0.2	7.72^{D}±0.2	7.48^{D}±0.1	7.60^{E}±0.2
F-test	17.25**	15.31**	8.21**	12.25**	13.51**	11.65**	16.20**

** High significant (p< 0.01).

Fig. (1): Control bread (72% extraction)

Fig.(2): Bread fortified with 10% flaxseeds

Fig. (3): Bread fortified with 10% chia seeds

Fig. (4): Bread fortified with 10% wheat germ

Fig. (5): Bread fortified with 5% moringapowder

Conclusion

In conclusion, this study demonstrates that the chemical composition of bread is fortified with natural sources of iron and calcium. The chemical composition of bread fortified with 10% (flax seeds, chia seeds, wheat germ) and 5% moringa powder were recorded the highest values of protein, crude fat, crude fiber and ash. While, the highest values in iron and calcium were recorded (33.81mg/100g, 242.20 mg/100g), respectively in bread fortified with 10% (flax seeds and chia seeds). Based on sensory characterises of bread fortified with 10% wheat germ were the best acceptable to the panellists. So (flax seeds, chia seeds, wheat germ and moringa powder) could be useful in different food formulations.

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القيمة الغذائية والتركيب الكيميائي للخبز المدعم بمصادر طبيعية من الحديد والكالسيوم

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الملخص

تهدف الدراسة الحالية إلى تقدير القيمة الغذائية والتركيب الكيميائي للخبز المدعم بنسبة ١٠٪ (بذور الكتان ، بذور الشيا ، جنين القمح) و ٥٪ مسحوق المورينجا كمصدر طبيعي للحديد والكالسيوم. علاوة على ذلك تم تقييم الخصائص الفيزيائية والتقييم الحسي للخبز المدعم المدروس. وأظهرت النتائج أن قيم البروتين والألياف الخام والكربوهيدرات في الخبز المدعم ب١٠٪ (بذور الكتان وبذور الشيا وجنين القمح) و٥٪ مسحوق المورينجا سجلت إرتفاعاً ملحوظاً في عينة الكنترول عند ($p < 0.05$) بينما أظهر التحليل الإحصائي للرماد والدهون الخام والسعرات الحرارية علي أساس الوزن الرطب قيماً أعلي في جميع العينات المدروسة والخبز الكنترول عند ($p < 0.01$). ومن ناحية أخرى أظهرت النتائج أنه لا يوجد فروق ذات دلالة إحصائية في محتوى الرطوبة في جميع العينات المدعمة والخبز الكنترول. بينما سجل محتوى الحديد والكالسيوم في الخبز المدعم (بذور الكتان ، بذور الشيا ، جنين القمح ومسحوق المورينجا) فروقاً معنوية عالية في عينة الخبز الكنترول. فسجل أعلى قيمة لمحتوى الحديد في الخبز المدعم بـ ١٠٪ بذور الكتان وكانت (٣٣،٨١مجم / ١٠٠ جرام) وأعلى قيمة لمحتوى الكالسيوم في الخبز المدعم بـ ١٠٪ بذور شيا كانت (٢٤٢،٢٠مجم / ١٠٠ جرام) مقارنة بجميع العينات. وكذلك سجل الخبز المدعم بنسبة ١٠٪ بذورالشياأعلى درجة من التقبل العام. بينما سجل الخبز

المدعم بمسحوق المورينجا ٥٪ أدنى درجة في التقبل العام. لذلك يمكن التوصية باستخدام (بذور الكتان وبذور الشياوجنين القمح) في المنتجات الغذائية كغذاء وظيفي وإثراء النظم الغذائية من أجل الاستفادة بشكل أفضل من الحديد والكالسيوم.

الكلمات المفتاحية: التركيب الكيميائي ، المحتويات المعدنية ، بذور الكتان ، بذور الشيا ، جنين القمح ، المورينجا ، الخبز.