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Utilization of Amaranth Flour in Preparation of High Nutritional Value Bakery Products

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Abstract

Amaranth has become an unconventional crop that interesting of scientists and researchers due to its unique nutritional properties, in addition to bear the water lack and be suitable for all types of soil. The objective of this study was to utilize amaranth flour in preparation of high nutritional value bakery products, crackers and tortilla produced by using amaranth flour instead of corn flour (w/w) by 0%, 25%, 50%, 75% and 100% levels substitution. The prepared products were evaluated for its chemical composition, minerals content, amino acids composition, fatty acid composition, color analysis, biological active compounds analysis and sensory evaluation. Results showed that substitution with amaranth flour increased protein, fat, ash and fiber. As for minerals and amino acid, it indicated that the formula No. 3 (25% corn flour/75% amaranth flour) in crackers and the formula No. 2 (50% corn flour/50% amaranth flour) in tortilla contained higher amount of minerals such as iron, calcium, potassium, zinc, magnesium, manganese, copper and phosphorus, and of the essential amino acids such as Leucine, Lysine and valine. On the other hand the formula No. 3 in crackers had the highest unsaturated fatty acids content and lowest of total saturated fatty acids content. While the formula No. 2 in tortilla had the highest saturated fatty acids content and lowest of unsaturated fatty acids content. The results also showed that the incorporation of amaranth flour in the preparation of the crackers and tortilla led to significantly decreased yellowness and lightness compared with control. Also, results indicated that crackers and tortilla which prepared with amaranth flour exhibited higher antioxidant activity than control formulas. Concerning sensory evaluation of crackers, results showed significant decrease in appearance, color and overall acceptability while, tortilla had significant decrease in general appearance, color and total score at all formulas. Based on the results obtained here, amaranth is a rich source of bioactive compounds and due to its nutritional benefits, it can be used in the develop-

ment and enhancement of functional foods.

Keywords

Amaranth, High Nutritional Value, Crackers, Tortilla, Nutritional Benefits

1. Introduction

Amaranth is one of the most promising crops that has attracted attention recently, because it bears the water lack and is suitable for all types of soil and its rapid growth [1] [2].

Amaranth contains high protein compared to most other grains such as wheat, rice and corn which are low in lysine content. In recent it has been used in developing countries as a way to overcome protein malnutrition and also it is become popular among patients with celiac disease because it does not cause allergic reactions in the intestinal mucosa, so it is used in preparation of gluten-free products [3] [4]. Grain amaranth contains from 13.1% to 21.00% protein, 5.6 to 10.9% crude fat, 3.1% to 5% fiber dietary and 2.5 to 4.4 ash, also rich sources minerals especially calcium, magnesium, copper, zinc, iron, potassium, and phosphorus and contains many bioactive compounds, especially phytosterols, polyphenols, saponins, and squalene [5] [6].

Maize (*Zea mays* L.) is one of the main crops and important all over the world. Also it is considered as good source of vitamins and dietary fiber [7]. And it found that maize seed contains moisture (11.6% - 20.0%), ash (1.10% - 2.95%), protein (4.50% - 9.87%), fat (2.17% - 4.43%), fiber (2.10% - 26.70%) and carbohydrates contents. Also it has a wide variety of uses directly as whole corn, corn flour, cornstarch, corn gluten, corn syrup, tortillas, tortilla chips, polenta cornmeal, corn oil, popcorn, cornflakes, etc. [7] [8].

Recently, fast snacks, especially crackers, have become one of the most widely consumed food products which is suitable for all age groups, because of its favorable texture and taste [9]. Also it is considered as crisp and thin and low in moisture content. It's usually prepared from wheat flour, water, fat, salt and sometimes low sugar. It can be used as an alternative to healthy snacks [10] [11] [12]. In addition, it's divided into three main types' soda crackers, snack crackers, and savory crackers [13].

Tortilla is one of the most popular foods consumed. It is considered as good source of calories because of its high content of starch. Also it is suitable to people suffering from gluten intolerance. It is known that corn lacks two types of essential amino acids, such as lysine and tryptophan, unfortunately the tortillas are lacking of vitamins and minerals, in addition, a good quality protein, so recently has been development with the addition of some other components, for example tortillas added with iron and micronutrients, tortilla made of amaranth flour and tortilla added with Flaxseed flour in order to improve its nutritional

characteristics [14] [15] [16] [17] [18].

Therefore, the present study is aimed to evaluate incorporation of amaranth flour in preparation of high nutritional value bakery products.

2. Materials and Methods

2.1. Materials

Amaranth flour obtained from harvest Company, Maize flour, sugar, salt, cumin, curcuma, red pepper, vegetable oil, baking powder and plastic bags were purchased from the local market, Cairo, Egypt. All chemicals and reagents used in this study were of analytical grade and Sigma Company.

2.2. Crackers Preparation

Crackers formulation is shown in Table 1. The dry ingredients including corn and amaranth flour, salt, cumin, curcuma, red pepper and baking powder except sugar were placed in the bowl of mixing for 30 s according to the method described by [19] then mixing wet ingredients alone (sugar, water and oil) for 30 s, then all the ingredients were mixed. Until we get dough, 10 min resting of dough at room temperature, and cut to the circular shape. After that the crackers were baked in the electric oven at 175˚C for 4 minutes, then cooled for 30 min, packaged in plastic bags and stored at room temperature.

2.3. Tortilla Preparation

Tortilla was processed as described by [16]. Tortilla was prepared by incorporating corn flour to amaranth flour at 25%, 50%, 75% and 100%. Control tortilla were prepared with corn flour without the incorporation of amaranth, the flour were mixed with the water then 10 min resting of dough. And it was divided into 50 g pieces. Then every pieces of dough shaped, into roller shape (2 mm thick and 15 diameter) and baked in electric oven at 250˚C for 5 min. and allowed to cool at room temperature, packed in polyethylene bags.

Table 1. Crackers formulation.

Ingredients	Samples				
	control	Formula (1)	Formula (2)	Formula (3)	Formula (4)
Corn flour (%)	100	75	50	25	-
Amaranth flour (%)	-	25	50	75	100
Oil vegetable (g)	10	10	10	10	10
Salt (g)	4	4	4	4	4
Sugar (g)	3	3	3	3	3
Cumin (g)	1	1	1	1	1
Curcuma (g)	2	2	2	2	2
Red pepper (g)	0.5	0.5	0.5	0.5	0.5
Baking powder (g)	2	2	2	2	2

2.4. Proximate Chemical Composition

Proximate Chemical composition including moisture, crude ether extract, crude protein, crude fiber and total ash were determined according to the AOAC [20].

2.5. Determination of Minerals

Minerals including Iron, Calcium, Potassium, Sodium, Magnesium, phosphorus, manganese, selenium, cooper and Zinc were measured in ash solution using ICP-OES Agilent 5100 VDV according to the US EPA [21].

2.6. Color Analysis

The color parameters which include lightness (L*), redness (a*) and yellowness (b*) of processed crackers were evaluated by a Hunter Lab Scan Visible colorimeter (USA) as described by [22].

2.7. Amino Acid Composition

Amino acid content was estimated as described by AOAC [20]. Amino acids were determined using High Performance Amino Acid Analyzer. Chemical Score was calculated according to FAO/WHO [23]

$$\text{C.S} = \frac{\text{mg of essential amino acid in g test protein}}{\text{mg of essential amino acid in requirement pattern}}$$

2.8. Fatty Acid Composition

Preparation of fatty acid methyl esters of oils extracted from corn, amaranth flour, and some products were performed according to the procedure of Radwan [24]. Using 1% sulphuric acid in absolute methanol, the fatty acid methyl esters obtained were separated by Shimodzu gas chromatograph (GC-4 CM-PFE) under the following conditions: column, 10% DEGS on 801100 chromosorb Q III; Detector temperature 270˚C: flow, N2 and chart speed, 5 min. Standard fatty acid methyl esters were used for identification. The area under each peak was measured by the triangulation method as percentage of each fatty acid was regard to the total area.

2.9. Bioactive Compounds

Determination of Total Phenols and Antioxidant Activity

The total phenolic contents as % Gallic acid of samples were determined by folin-Ciocalteau regent (1:10 diluted) was added to 0.2 ml of methanolic extract after 4 min thus 0.8 ml of Na_2CO_3 solution and after 30 min incubation at the room temperature, thus, the samples were centrifuged at 5000 rpm for 10 min. the absorbance was measured at 765 nm [25].

Radical scavenging activity of samples was measured using the DPPH (2, 2-diphenyl-1-picrylhydrazyl) according to the procedure described by [26]. The percentage of DPPH scavenging for samples was calculated as follows:

$$\text{Scavenging DPPH\%} = [\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}}) \times 100/\text{Asb}_{\text{control}}$$

2.10. Sensory Evaluation of Crackers and Tortilla

Appearance, color, odor, taste, crispiness, and overall acceptability of all the crackers products prepared from different percentages of amaranth and corn flour were assessed using 10 staff members of Special Food and Nutrition and Crops Technology Research Department, Food Technology Research Institute, Egypt. The panelists were asked to score the above attributes according to standard hedonic rating scale from 9 (like extremely) to 1 (dislike extremely) according to [27]. with regard to the sensory evaluation of tortilla were evaluated as described by [28] which including general appearance, roundness, color, taste and odor by 20, 20, 20, 20 and 20, degree, respectively with total score (100) by a trained taste panel (n/10) of Food Technology Research Institute, Agricultural Research Centre, Giza Egypt.

2.11. Statistical Analysis

All data of the present study were expressed as mean values ± SD Statistical analysis system (SAS) software program SAS Institute [29] was carried out by two-way analysis of variance (ANOVA) followed by using t Tests (LSD) at $p \leq 0.05$ which indicated statistically significant difference.

3. Results and Discussion

3.1. Proximate Chemical Composition of Raw Material

Proximate chemical composition of raw material is shown in **Table 2**. The results of proximate chemical composition indicated that Amaranth flour is significantly superior in crude protein, Ash, crude fiber and carbohydrates (15.38%, 2.54%, 3.55% and 65.69% respectively) compared with corn flour. On the other hand, corn flour contained significant higher amounts of moisture, carbohydrates and energy values (11.11% and 344.56 Kcal/100g, respectively), whereas the crude ether extract content is near equal in each amaranth and corn flour (4.22%, 4.00%, respectively). These results are nearly in agreement with those found by [30] found that the moisture, crude protein, ash, crude fiber and crude ether extract in amaranth flour were (8.13%, 15.05%, 2.93%, 3.00% and 6.68% respectively). Also [31] found that the corn flour contains 12.15% moisture, 9.08% crude protein, 1.60% ash, 1.25% crude fiber and 1.15% crude ether extract.

3.2. Proximate Chemical Composition of Crackers and Tortilla

The proximate chemical composition of crackers was shown in **Table 3**. It could be noticed that the incorporation of amaranth flour in the preparation of the crackers increased significantly the moisture content which ranged between 5.80% and 10.36%. The highest value of moisture content was for the Formula No 4, while the lowest content was for the control sample. This value is higher than to the value of 5.85% which reported by [32], also [33] mentioned that the moisture content of crackers ranged from 2.50% to 3.50%, and this is acceptable in most fresh baked.

Table 2. Proximate chemical composition of raw material.

Components	Flour		L.S.D
	Amaranth	Corn	
Moisture	8.62 ± 0.33[b]	11.11 ± 1.34[a]	2.22
Crude protein (N × 6.25)	15.38 ± 0.38[a]	7.09 ± 0.12[b]	0.64
Crude ether extract	4.22 ± 0.84[a]	4.00 ± 0.50[a]	1.57
Ash	2.54 ± 0.10[a]	1.00 ± 0.33[b]	0.55
carbohydrate	65.69 ± 1.71[b]	75.37 ± 0.35[a]	3.82
Crude fiber	3.55 ± 0.51[a]	1.43 ± 0.40[b]	1.04
Energy Value(Kcal/100g)	316.10 ± 1.22[b]	344.56 ± 2.38[a]	4.28

Values followed by the same letter in a row are not significantly different at $p < 0.05$.

Table 3. Proximate chemical composition of crackers.

Components	Formulas					
	Control	Formula (1)	Formula (2)	Formula (3)	Formula (4)	L.S.D
Moisture	5.80 ± 0.08[d]	9.18 ± 0.08[c]	10.00 ± 0.11[b]	10.20 ± 0.03[ab]	10.36 ± 0.08[a]	0.22
Crude protein (N × 6.25)	4.93 ± 0.01[e]	6.09 ± 0.12[b]	7.58 ± 0.04[c]	8.83 ± 0.09[b]	10.27 ± 0.08[a]	0.16
Crude ether extract	6.38 ± 0.08[c]	6.52 ± 0.14[cb]	6.59 ± 0.01[b]	6.89 ± 0.04[a]	7.00 ± 0.03[a]	0.19
Ash	5.25 ± 0.00[b]	5.36 ± 0.01[b]	5.57 ± 0.06[a]	5.58 ± 0.05[a]	5.71 ± 0.11[a]	0.15
carbohydrate	76.22 ± 0.07[a]	70.95 ± 0.14[b]	67.86 ± 0.29[c]	65.79 ± 0.06[d]	64.00 ± 0.16[e]	0.43
Crude fiber	1.43 ± 0.09[d]	1.90 ± 0.01[c]	2.41 ± 0.06[b]	2.73 ± 0.05[a]	2.67 ± 0.07[a]	0.16
Energy value (Kcal/100g)	367.19 ± 0.40[a]	348.57 ± 0.65[b]	338.31 ± 0.99[c]	333.93 ± 0.16[d]	329.25 ± 0.98[e]	1.84

Values followed by the same letter in a row are not significantly different at $p < 0.05$.

Also, as stated in **Table 3**, it indicated that the incorporation of amaranth flour increased significantly the protein content of the formulas from 4.93% to 10.27%, the highest value in formula No 4 whereas the lowest value in control sample. As well as observed the protein content increased as the substitution percentage increased. It is a nutritional characteristic that provides more protein needs. [34] found that amaranth flour is used to preparation some products this provides more than 13% of protein. These results are in agreement with those found by [35] and [36]. Crude ether extract in the crackers ranged from 6.38% to 7.00%. These values are comparable to the value of 6.5% as reported by [35]. Furthermore fiber content increased significantly by increasing the substitution level of amaranth flour. The highest value of fiber content was observed in formula No. 3 (2.73%) followed by formula No. 4 (2.67%) relative to control and other formulas. Results also, indicated that slightly reduction in carbohydrates of crackers prepared with amaranth and corn flour compared to corn flour control due to the high content in protein, fat, total fiber and moisture of amaranth flour [37]. Ash content increased in formula No. 4 followed by formula No. 3 relative to corn flour control (5.71%, 5.58% and 5.25%, respectively) the highest ash

content of the amaranth crackers is due to the pericarp which remains with the grain after milling. [38] who mentioned that replacing wheat flour with 40% amaranth flour led to increase the ash content in bread from 1.35 g/100g to 2.06 g/100g.

Regarding to energy values were observed significant differences in formulas and had lowest for formula No 4 whereas the highest for control sample. The protein, total carbohydrates content except moisture of crackers were similar to those found by [32] who mentioned 10.34% protein, 69.03% total carbohydrates and 5.85% moisture in amaranth bars snack.

As for chemical composition of tortilla are shown in **Table 4**. It could be observed that by increasing the substitution level of amaranth flour, the moisture content increased where the moisture content was in control sample (4.50%) and formula No. 4 (5.91%) and there were significant differences between the control sample and all formulas. Protein content was increased with increasing the substitution level of amaranth flour where in control sample (6.31%) and formula No 4 (11.99%). Also observed the incorporation of amaranth flour increased significantly crude ether extract content which was in control sample (3.09%) and formula No. 4 (4.10%). Further increased the substitution led to increase the ash where it was (2.88%) in control sample and (3.94%) in formula No. 4. As well as the fiber increased, it was in the control sample and formula No. 4 (0.85%, 2.10% respectively). As for carbohydrates and energy values, there was a significant decrease in carbohydrate content and energy values by increasing substitution rate which was (82.39%, 363.62 Kcal/100g, respectively) in the control sample and decreased to (71.98%, 336.76 Kcal/100g, respectively) in formula No. 4. These results are in agreement with those found by [39] who stated that amaranth flour incorporation to tortilla increased protein and fat contents as well as ash contents, however, decreased carbohydrate content.

3.3. Mineral Content of Raw Materials

Mineral contents of Corn and amaranth flour are given in **Table 5**. The results indicated that amaranth flour is superior to corn flour in most minerals such as iron, calcium, potassium, zinc, magnesium and phosphorus (27.50, 687, 2163.50, 21, 705.75 and 1693 mg/100g, respectively). On the other hand, corn flour contains high amounts of copper, selenium, manganese and sodium (1.56, 1.04, 10.01 and 51.59 mg/100g, respectively) compared with amaranth flour. The data obtained in the present study are similar mostly with those reported by [40] and [41] they found that amaranth considered as good source of some minerals such as iron, copper, manganese and zinc.

3.4. Mineral Content of Crackers and Tortilla

The data in **Table 6** showed that mineral contents of crackers and tortilla observed the most minerals such as iron, calcium, potassium, zinc, magnesium, manganese copper and phosphorus content of Control Crackers were found to

Table 4. Proximate chemical composition of tortilla.

Components	Formulas					
	control	Formula (1)	Formula (2)	Formula (3)	Formula (4)	L.S.D
Moisture	4.50 ± 0.11^{c}	5.67 ± 0.13^{b}	5.85 ± 0.07^{ab}	5.88 ± 0.04^{ab}	5.91 ± 0.06^{a}	0.22
Crude protein (N × 6.25)	6.31 ± 0.03^{e}	7.08 ± 0.00^{d}	9.84 ± 0.02^{c}	10.32 ± 0.08^{b}	11.99 ± 0.18^{e}	0.23
Crude ether extract	3.09 ± 0.02^{c}	3.43 ± 0.01^{b}	3.51 ± 0.00^{b}	3.59 ± 0.04^{b}	4.10 ± 0.01^{a}	0.15
Ash	2.88 ± 0.02^{c}	3.14 ± 0.03^{c}	3.57 ± 0.06^{a}	3.59 ± 0.04^{b}	3.94 ± 0.01^{a}	0.06
carbohydrate	82.39 ± 0.11^{a}	79.62 ± 0.21^{b}	75.83 ± 0.24^{c}	75.05` ± 0.08^{d}	71.98 ± 0.24^{e}	0.48
Crude fiber	0.85 ± 0.03^{e}	1.07 ± 0.04^{d}	1.41 ± 0.02^{c}	1.61 ± 0.02^{b}	2.10 ± 0.01^{a}	0.06
Energy value (Kcal/100g)	363.62 ± 0.21^{a}	356.41 ± 0.69^{c}	344.75 ± 0.21^{c}	342.76 ± 0.04^{d}	336.76 ± 0.85^{e}	1.30

Values followed by the same letter in a row are not significantly different at $p < 0.05$.

Table 5. Minerals content of corn and amaranth flour (mg/100g) on dry weight basis.

Samples	Element									
	Fe	Ca	K	Na	Zn	Mg	Mn	Cu	Se	P
Corn flour	23.74	557.25	1133.50	51.59	12.28	621.25	10.01	1.56	1.04	1389.30
Amaranth flour	27.50	687	2163.50	40.34	21.00	705.75	2.8	1.30	0.50	1693.00

Table 6. Minerals content of crackers and tortilla (mg/100g) on dry weight basis.

Element	Crackers Control	Formula 3	Tortilla Control	Formula 2
Fe	13.60	17.25	12.00	12.25
Ca	218.25	636.50	222.00	502.25
K	1191.00	1395.50	1451.50	1885.75
Na	245.06	234.87	114.29	128.85
Zn	8.75	11.75	10.25	11.25
Mg	335.75	731.51	358.50	687.75
Mn	2.15	7.90	2.08	5.80
Cu	1.03	1.50	1.25	1.30
Se	0.50	0.50	0.50	0.50
P	1291.75	2217.75	1009.00	1729.50

be 13.60, 218.25, 1191.00, 8.75.335.75, 2.15, 1.03 and 1291.75 mg/100g, respectively which increased to (17.25, 636.50, 1395.50, 11.75, 731.51, 7.90, 1.50 and 2217.75 mg/100g, respectively) in formula No.3 (25% corn flour and 75% amaranth flour). On the other hand, the sodium content in the formula has decreased compared to Control Crackers. Regarding tortilla, the results indicate that the formula No. 2 contains high amounts of iron, calcium, potassium, sodium, zinc, magnesium, manganese copper and phosphorus compared with Control tortilla.

[42] stated that amaranth flour incorporation at the level of 40% in preparation Chapatti bread significantly increased calcium, magnesium, iron, copper and zinc content, Where calcium, magnesium and iron increased by 103.5%, 60.2% and 76.29%, respectively.

3.5. Color Analysis

Color is one of the most important factors determining the acceptability of food products by the consumer. Color is one of the most important sensory characteristics that play an important role in consumer choice and preference for any food product. The color parameters which including (lightness, redness and yellowness) of preparation crackers were measured by Hunter lab instrument **Table 7**. It was obvious that the highest value of lightness was found in corn flour. On the contrary, to formula No 3 which possessed the lowest lightness, whereas, the other formulas lied in between. The studied formulas could be arranged according to redness value in the following descending order: control sample, formula No. 2, formula No. 1, formula No. 3, formula No. 4, amaranth flour and corn flour. Control sample showed the highest value in yellowness On the contrary amaranth flour had record the lowest yellowness. The similar results were found by [32] they reported that lightness decreased with increased levels of amaranth flour in cookies. This may be due to a negative relationship between protein

Table 7. Color analysis of crackers and tortilla.

Samples	Color		
	L*	a*	b*
Amaranth flour	89.68 ± 0.25^{b}	1.54 ± 0.12^{d}	14.27 ± 0.61^{e}
Corn flour	92.88 ± 0.33^{a}	1.10 ± 0.10^{d}	31.12 ± 0.94b
control	70.07 ± 1.35^{c}	9.02 ± 0.25^{a}	35.26 ± 1.41^{a}
Formula (1)	68.35 ± 0.68^{c}	6.41 ± 0.27^{b}	31.39 ± 2.06^{b}
Formula (2)	64.56 ± 3.00^{d}	6.48 ± 1.18^{b}	26.95 ± 1.41^{c}
Formula (3)	61.46 ± 1.85^{e}	5.64 ± 0.69^{cb}	22.96 ± 2.34^{d}
Formula (4)	67.19 ± 1.06^{c}	4.80 ± 0.66^{c}	27.31 ± 1.08^{c}
L.S.D	2.65	1.04	2.66
	Tortilla		
control	88.84 ± 1.47^{a}	2.85 ± 0.47^{b}	27.80 ± 0.47^{a}
Formula (1)	85.86 ± 1.31^{a}	4.08 ± 0.92^{a}	27.20 ± 0.61^{a}
Formula (2)	84.23 ± 1.47^{a}	3.62 ± 0.38^{ab}	26.60 ± 1.54^{a}
Formula (3)	76.87 ± 3.16^{b}	3.75 ± 0.56^{ab}	24.70 ± 1.39^{b}
Formula (4)	64.50 ± 3.23^{c}	3.89 ± 0.61^{ab}	22.85 ± 0.70^{b}
L.S.D	4.29	1.12	1.89

Values followed by the same letter in a row are not significantly different at $p < 0.05$. L* value is a measure of lightness ranging from 0 (black) to 100 (white), the a* value ranges from −100 (greenness) to +100 (redness), the b*value ranges from −100 (blueness) to +100 (yellowness).

content and lightness. As well as Millard reaction also plays a major role in color formation which occurs during baking.

The data in Table 7 show that the replacement of corn flour with different amounts of amaranth flour caused decrease of L value of tortilla samples in ranged from 85.43 to 64.50 compared to the control tortilla (L = 88.84). The higher reduction of lightness values was observed in formula No 4 in compare with control. However, redness values were increased via the substitution with amaranth flour which ranged from 2.85 to 3.89 while the highest content was in formula No. 4 meanwhile the control recorded the lowest value of redness. Finally, the yellowness value was higher in control sample in compare with other prepared formulas.

3.6. Amino Acids Composition

The amino acids compositions of raw material which include corn and amaranth flour are shown in Table 8. It was noticed that amaranth flour is higher than corn flour in each essential amino acid and found amaranth flour was contained

Table 8. Amino acid composition of raw material.

Amino acid (g/100g) protein	Corn flour	Amaranth flour
Essential A.A.		
Lysine	0.22	0.82
Methionine	0.17	0.43
Lucien	0.56	0.79
Isoleucine	0.19	0.51
Phenylalanine	0.23	0.56
Cysteine	0.18	0.54
Threonine	0.22	0.48
Tyrosine	0.22	0.53
Valine	0.32	0.64
Histidine	0.20	0.38
Total essential A.A	2.51	5.68
Non-essential A.A		
Alanine	0.48	0.59
Arginine	0.34	1.23
Glutamic	1.09	2.47
Glycine	0.22	0.95
Aspartic	0.40	1.23
Serine	0.27	0.66
Proline	0.50	0.53
Total Non-essential A.A	3.30	7.66

higher amounts of lysine, leucine and valine (0.82, 0.79 and 0.64 g/100g, respectively) as compared to those corn flour (0.22, 0.56 and 0.32 g/100g, respectively). Regarding non-essential amino acid, it could be noticed Arginine, glutamic and Aspartic (1.23 g/100g, 2.47 g/100g and 1.23 g/100g protein, respectively) in amaranth flour was higher amounts compared to those Corn flour (0.34, 1.09 and 0.40 g/100g, respectively). These results are agreement with those reported by [43] who found that the non-essential amino acid (Arginine, glutamic and Aspartic) high content in amaranth flour were recorder 1.47 g/100g, 2.51 g/100g and 1.22 g/100g, respectively. As well as amaranth flour has a high concentration of the essential amino acids such as lysine, leucine, and phenylalanine.

3.7. Amino Acids of Crackers and Tortilla

The crackers prepared from 75% amaranth and 25% corn flour was analyzed for its amino acids composition which were the best among others as shown in Table 9. It's contained high percentage of the essential amino acids which including

Table 9. Amino acid composition of crackers and tortilla.

Amino acid (g/100g) protein	crackers Control	*CS	Formula 3	*CS	tortilla Control	*CS	Formula2	*CS	FAO/WHO Pattern (2002)
Essential A.A									
Lysine	0.14	2.6	0.41	7.88	0.17	3.27	0.43	8.27	5.2
Methionine	0.13	5.91	0.22	10.00	0.14	6.36	0.26	11.82	2.2
LeIucine	0.46	7.30	0.54	8.57	0.52	8.25	0.67	10.64	6.3
Isoleucine	0.17	4.05	0.33	7.86	0.23	5.48	0.36	8.57	4.2
Phenylalanine	0.20	7.14	0.36	12.86	0.22	7.86	0.39	13.93	2.8
Cysteine	0.17		0.23		0.17		0.28		
Threonine	0.17	6.30	0.32	11.85	0.20	7.41	0.35	12.96	2.7
Tyrosine	0.19		0.33		0.20		0.38		
Valine	0.26	6.19	0.40	9.52	0.30	7.14	0.42	10.00	4.2
Histidine	0.15	8.33	0.26	14.44	0.19	10.56	0.28	15.56	1.8
Total essential A.A	2.04	47.82	3.40	82.98	2.34	56.33	3.82	91.75	29.40
Non-essential A.A									
Alanine	0.31		0.40		0.46		0.48		
Arginine	0.24		0.62		0.30		0.75		
Glutamic	0.78		1.33		0.85		1.72		
Glycine	0.22		0.60		0.25		0.60		
Aspartic	0.32		0.65		0.38		0.77		
Serine	0.19		0.46		0.21		0.50		
Proline	0.32		0.33		0.49		0.47		
Total Non-essential A.A	2.38		4.39		2.94		5.29		

(Leucine, Lysine and valine, 0.54, 0.41 and 0.40 g/100g, respectively) as compared to control sample. Also found that Formula No 3 had higher content of Glutamic, Aspartic and Arginine.

As shown in Table 9. The Formula No. 2 (50% amaranth and 50% corn flour) of tortilla contained higher amounts of leucine, lysine and valine. Further that glutamic acid aspartic acid, and Arginine were the major abundant amino acids in the Formula No. 2 with values (1.72, 0.77 and 0.75 g/100g, respectively). The present data are consistent with [42] who revealed that chapatti fortified with amaranth flour (40%) showed contained higher of lysine. As well [17] who observed increase lysine content in tortilla containing of amaranth flour (7%).

3.8. Fatty Acid of Crackers and Tortilla

The fatty acid composition of data is presented in Table 10. The fatty acid pattern revealed that total saturated content were 16.17% and 22.32% for Corn and amaranth flour, respectively, while the total unsaturated fatty acids were 83.83% and 77.78%, respectively. Linoleic acid and oleic acid were found to be the dominant fatty acid 46.18% and 35.58% respectively, in Corn flour, while Docosadienoic acid was found (8.45%) in amaranth flour only. these results agreed well

Table 10. Fatty acid of crackers and tortilla.

Fatty acids	Amaranth flour	Corn flour	Crackers Control	Formula 3	Tortilla Control	Formula 2
Myrsitic	0.18	-	-	0.11	-	0.15
Pentadecanoic	0.07	-	-	0.03	-	0.09
Palmitic	17.04	12.58	10.70	8.70	13.81	13.35
Palmitoleic	0.18	0.18	0.11	0.10	0.15	0.16
Heptadecanoic	0.17	0.11	0.13	0.13	1.09	0.15
Heptadecenoic	0.09	0.05	0.06	0.03	0.04	0.04
Stearic	3.41	2.59	3.27	3.35	3.42	5.39
Oleic	22.6	35.58	27.49	26.57	33.82	27.11
Linoleic	43.29	46.18	56.35	51.04	45.08	44.26
Linolenic	1.16	1.45	0.33	0.91	1.35	1.07
Eicosenoic	0.30	0.39	0.21	0.19	0.37	0.33
Arachidic	0.85	0.68	0.76	0.51	0.67	0.92
Behenic	0.34	0.21	0.59	0.62	0.20	0.32
Docosadienoic	8.45	-	-	6.30	-	5.15
Docosatrienoic	0.78	-	-	0.52	-	0.40
Docosatetraenoic	0.83	-	-	0.74	-	0.80
Lignoceric	0.26	-	-	0.15	-	0.31
Total saturated (TS)	22.32	16.17	15.45	13.59	19.19	20.68
Total unsaturated (TU)	77.68	83.83	84.55	86.40	80.81	79.32

with those reported by [44] who found that Linoleic acids ranged between (37% - 62%) in amaranth, while maize were content (50%) and amaranth oil is very like to maize in oleic acid content. Also [45] found that the total unsaturated fatty acids content of the amaranth flour ranged from 76.2% to 77.6% while saturated fatty acids were 22.4% to 22.8%. As well [46] indicated that linoleic acid and oleic acid were the major fatty acid represented about (40.76% and 27.88% respectively).

As for the crackers, It observed that by increasing the substitution level of amaranth flour, the total saturated fatty acids decreased where the total saturated fatty acids content was in control sample (15.45%) and formula No. 3 (13.59%). on the contrary the total unsaturated fatty acids increased from 84.55% in the control sample to 86.40% in formula No. 3. [47] and [48] stated that amaranth flour are a good source in polyunsaturated fatty acids, and it is recommended for use in functional foods to prevent cardiovascular disease, Also its use in diets increases unsaturated fatty acids and natural antioxidants that play an important role in protecting cellular membranes from oxidative damage.

From data in **Table 10**, it could be noticed that the by increasing substitution level of amaranth flour in tortilla led to increase in total saturated fatty acids from 19.19% in control sample to 20.68% in formula No. 2, due to the decrease of unsaturated fatty acids caused by oxidation. On the other hand, the total unsaturated fatty acids decreased to 79.32% in formula No 2 comparing with the control sample (80.81%). Data presented here agree with the results obtained in the study of [45] who found that the addition of amaranth flour to Complementary Food led to increase in total saturated fatty acids and decrease of unsaturated fatty acids and the Linoleic and oleic acid were the dominant unsaturated fatty acids in the product 36.3% and 35.9% respectively.

3.9. Total Phenolic Content and Antioxidant Activity

The data in **Table 11** show the Bioactive Compounds as well as the antioxidant activity of amaranth, corn flour and bakery products which including cracker and tortilla. It can be noted that amaranth flour contained 1001.7 mg/100 g total phenolic content, while corn flour contained 916.00 mg/100g. As for crackers, found that crackers control were contained higher amounts of total phenolic content (853.3 mg/100g) while the lowest contents value was (841.4 mg/100g) found in formula No. 3. In case of tortilla, it can be noted that the amaranth flour added led to significantly increased by total phenolic content from 891.2 to 940.5 mg/100g in tortilla control and formula No. 2, respectively. These values are more than mentioned by [49] who found the total phenolic content of the amaranth

Table 11. Bioactive compound of raw material and bakery products.

Bioactive Compounds	Amaranth Flour	Corn Flour	Crackers Control	Formula 3	Tortilla Control	Formula 2
Total Phenolic Content (mg/100g)	1001.7^{a} ±29.9	916.0^{bc} ± 4.79	853.3^{de} ± 5.93	841.4^{e} ± 17.1	891.2^{cd} ± 35.8	940.5^{b} ± 16.6
Antioxidant Activity (%)	94.9^{a} ±0.26	94.2^{a} ± 0.61	90.8^{c} ± 0.50	91.3^{c} ± 0.77	92.6^{b} ± 0.44	93.3^{b} ± 0.26

flour were 185.0 GAE equivalents (mg GAE/100g). Also [50] found that cooking methods such as boiling and baking lead to a decrease in total phenolic compounds.

The results indicated that antioxidant activity in amaranth and corn flour were 94.9% and 94.2%, respectively. As well as shown the replacement of corn flour with different amounts of amaranth flour caused significant increase of antioxidant activity of crackers which was 91.3% in formula No. 3 compared to the crackers control (90.8%). In case of tortilla also caused significant increase of antioxidant activity which ranged from 92.6% to 93.3% in tortilla control and formula No. 2, respectively. The data obtained in the present study are in agreement with those reported by [30] who found that cookies fortified with Germinated amaranth flour showed higher value of antioxidant activity. The increased antioxidant activity may be due to that during baking processes a dark color pigments (brown color) which formed from the Millard reaction and this acts as an antioxidant activity.

3.10. Sensory Evaluation

Results of sensory evaluation such as appearance, color, odor, taste, Crispiness, and overall acceptability are presented in **Table 12**. It could be observed that all the formulas there significant decrease in appearance, color and overall acceptability. No significant change was observed in odor of crackers containing amaranth flour up to 100% level. In terms of taste, it significantly decreases in mean scores of all the Formulas. This may be due to bitter aftertaste of amaranth flour. As for the Crispiness indicated that of crackers remained almost constant among Formulas except formula No. 3 (25% corn flour and 75% amaranth flour) and formula No. 4 (100% amaranth flour). Moisture plays an important and pivotal role in bakery products as it affects texture, crispness and shelf life in storage. Also their increase leads to a deterioration in the qualities of the final product [13]. These results agreed well with those reported by [49] who found that when increase amaranth flour the appearance, odor, taste, color, crispness and overall acceptability were decreased. This may be caused the amaranth flour is a rich source of dietary fiber and protein.

Regarding sensory evaluation of tortilla, the results are shown in **Table 13**.

Table 12. Sensory evaluation of crackers.

Formulas	Appearance	Color	Odor	Taste	Crispiness	Overall acceptability
control	$8.90^{a} \pm 0.32$	$9.00^{a} \pm 0.00$	$8.70^{a} \pm 6.3$	$8.60^{a} \pm 0.46$	$7.55^{b} \pm 0.44$	$8.54^{a} \pm 0.44$
Formula (1)	$8.35^{b} \pm 0.47$	$8.55^{b} \pm 0.50$	$8.80^{a} \pm 0.42$	$7.90^{bc} \pm 0.74$	$7.55^{b} \pm 0.50$	$8.14^{ab} \pm 0.40$
Formula (2)	$7.80^{c} \pm 0.50$	$8.35^{bc} \pm 0.53$	$8.35^{a} \pm 0.71$	$7.8^{bc} \pm 0.59$	$7.55^{b} \pm 0.76$	$7.80^{b} \pm 0.48$
Formula (3)	$7.80^{c} \pm 0.54$	$7.95^{c} \pm 0.28$	$8.45^{a} \pm 0.50$	$8.40^{ab} \pm 0.57$	$8.60^{a} \pm 0.52$	$8.20^{ab} \pm 0.36$
Formula (4)	$7.45^{c} \pm 1.60$	$7.90^{c} \pm 1.69$	$8.10^{a} \pm 1.77$	$7.55^{c} \pm 1.70$	$8.40^{a} \pm 1.77$	$7.98^{b} \pm 1.70$
L.S.D	0.44	0.40	0.56	0.52	0.50	0.38

Values followed by the same letter in a row are not significantly different at $p < 0.05$.

Table 13. Sensory evaluation of tortilla.

Formulas	General Appearance	Color	Odor	Taste	Round	Total Score
control	$9.00^{a} \pm 0.00$	$8.90^{a} \pm 0.22$	$8.60^{ab} \pm 0.52$	$8.20^{ab} \pm 0.79$	$8.60^{ab} \pm 0.35$	$8.60^{a} \pm 0.26$
Formula (1)	$8.60^{b} \pm 0.52$	$8.30^{ab} \pm 0.42$	$8.80^{a} \pm 0.35$	$8.50^{a} \pm 0.53$	$8.75^{a} \pm 0.42$	$8.59^{a} \pm 0.20$
Formula (2)	$8.30^{b} \pm 0.48$	$7.90^{bc} \pm 0.84$	$8.50^{ab} \pm 0.67$	$8.15^{abc} \pm 0.85$	$8.25^{ab} \pm 0.59$	$8.22^{a} \pm 0.41$
Formula (3)	$7.65^{c} \pm 0.41$	$7.25^{c} \pm 0.79$	$8.25^{ab} \pm 0.89$	$7.55^{bc} \pm 0.86$	$7.85^{b} \pm 0.97$	$7.71^{b} \pm 0.64$
Formula (4)	$7.25^{d} \pm 0.42$	$7.90^{c} \pm 1.69$	$8.00^{b} \pm 0.82$	$7.35^{c} \pm 1.11$	$8.05^{ab} \pm 1.12$	$7.61^{b} \pm 0.70$
L.S.D	0.37	0.66	0.61	0.76	0.68	0.44

Values followed by the same letter in a row are not significantly different at $p < 0.05$.

all the formulas there significant decrease in General Appearance, color and Total Score, Also observed the formula No 1 exhibited superior significantly ($p \leq 0.05$) odor and taste comparing with the other formulas. The present data are consistent with [30] who revealed that, Cookies containing 100% amaranth flour showed decrease value of taste, odor and overall acceptability score. This may be because the amaranth flour has a bitter taste also the similar results were found by [51] who reported that the cookies prepared from 25% addition of amaranth flour was accepted by the panelists.

4. Conclusion

From the results presented in this work, it can be concluded that the use of amaranth flour improved chemical composition, physiochemical properties, essential amino acids, essential unsaturated fatty acids and minerals which play an active role in improving the nutritional value of crackers and tortilla. This is because it is an important source of protein, and minerals especially calcium, magnesium, copper, zinc, iron, potassium, and phosphorus, and contains many bioactive compounds, especially phytosterols, polyphenols. In addition, it's considered as a good source of oils which contain omega fatty acids (linoleic and linolenic acids).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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