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Enhancing the Nutritional Value of Corn Flakes by Adding Quinoa Flour

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Abstract
The effect of replacing yellow corn flour (YCF) by quinoa flour (QF) at different levels (20, 40, 60, 80, and 100%) on the nutritional values, phenolics, flavonoids compounds, antioxidant activity, color quality, and sensory evaluation of produced corn-quinoa flakes was investigated. Results revealed that substituting yellow corn flour with different levels of QF caused a significant increase *(P<0.05)* in crude protein, ether extract, crude fiber and ash content, while carbohydrates content decreased. Also, the contents of minerals (Ca, P, Mg, K, Fe, and Zn) and essential amino acids (Histidine, Lysine, Isoleucine, Threonine, Methionine+Cystein and Phenylalanine+Tyrosine) were contained increased gradually by increasing replacement levels of QF from 20% to 100% in all tested samples compared with control. In this concern, the results indicated that the incorporation of QF in YCF led to a significant increase *(P<0.05)* in the total content of phenolics, flavonoids compounds, and antioxidant activity of prepared corn-quinoa flakes by increasing of QF ratio in the flakes formulation. Color values of produced corn-quinoa flakes indicated that *L** and *b** values of produced flakes decreased gradually with increasing the substitution amount from 20 to 100% QF compared with the control sample. While *a** values increased significantly with increasing the replacement levels of QF compared with the control. Sensory evaluation tests showed that up to 40% of YCF could be replaced with QF in produced flakes and still more acceptable for consumers than the control sample prepared from 100% YCF. Thus, it can be suggested that combining QF in YCF led to strengthening and improving the national values of produced flakes.
Keywords: Chemical analysis, Corn flakes, Nutritional value, Quinoa flour, Sensory evaluation.

1. Introduction

Cereal grains are a wide foodstuff consumed in most countries and provide most of the caloric energy, proteins, minerals, and vitamins for the world population **(1)**. Ready-to-eat (RTE) breakfast cereals have become a staple established on breakfast tables almost all over the world and are defined as "a food made from processed grains such as corn, wheat, oat, and other grains usually with added flavor and fortifying ingredients for human consumption". The global edible flakes market was valued at USD 17.43 billion in 2019 and is expected to grow significantly (**2**). Breakfast cereals are important sources

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of minerals, vitamins, antioxidants, and phytochemicals (**3** and **4**).

Corn flakes are the most popular breakfast cereals in the daily diet for children and adolescents. Mize or corn (*Zea mays* L.) is the major raw material used to manufacture corn flakes. It has a good source of minerals, vitamins, and some phytochemical components **(5).** On the other side, corn proteins have poor nutritional value for humans because they have limited amounts of some essential amino acids such as lysine and tryptophan which average (about 2%) are less than one-half of the recommended concentration for human nutrition **(6** and **7).**

Quinoa (*Chenopodium quinoa*, *Willd*.) is a pseudo cereal belonging to (*Chenopodiaceae)*. Quinoa seeds have been consumed to make breakfast cereal or ground to flour to produce toasted and baked goods such as; cookies, biscuits, bread, noodles, and flakes **(8)**. Quinoa seeds can be considered a very healthy, nutritious cereal compared to commonly consumed cereals such as wheat, barley, and corn **(9)**. It has a rich source of protein, all essential amino acids, full of vitamins/minerals, essential fatty acids, dietary fiber, other beneficial compounds, and a low glycemic index. It can be used in breakfast flakes, provides energy, and aids in weight loss **(10, 11,** and **12).** The amino acid value is higher than wheat and corn, and a more incredible amount of lysine makes quinoa superior to other cereals **(13)**.

Quinoa-based foods play a beneficial role in reducing childhood malnutrition **(14)**; reducing risk of developing cardiovascular disease **(15)**; diabetes **(16)**; anti-obesity **(17)**; people with anemia **(18)**; individuals with lactose intolerance **(19)**; women prone to osteoporosis **(20)** and celiac disease **(21)** due to its properties including a high nutritional value, therapeutic features, and gluten-free content.

The present research aimed to assess the proximate chemical composition, amino acids, minerals content and some phytochemicals of corn flakes supplemented with quinoa flour as a good source of essential amino acids and other nutrients as assessing the color quality and sensory properties of products.

2. Materials and Methods

2.1. Materials

Yellow corn flour was purchased from the Egyptian-Italian Company for maize products (Maiza), 10^{th} of Ramadan City, Sharquia, Egypt. Quinoa seeds were obtained from Field Crops Research Institute, Agriculture Research Center, Giza, Egypt. All chemicals used in this study for analysis were of analytical grade and purchased from Delta Aromatic International Company, Giza, Egypt.

2.2. Methods

2.2.1. Preparation of quinoa flour (QF)

Quinoa seeds were cleaned from dust, broken seeds, and other foreign matters. The seeds were washed many times with tap water in a tank equipped with a mixer until there was no more foam in the washing water to remove saponins. Afterward, the seeds were rinsed and dried in an electric oven at 50±2°C for 12 hr. The quinoa seeds were milled to a fine powder in an electric grinder of stainless steel using a laboratory disc mill and sifted through a 60 mesh to obtain quinoa flour **(22).**

2.2. 2. Preparation of Corn-Quinoa flour blends:

Six blends were prepared by mixing yellow corn flour (YCF) with quinoa flour

(QF) using an electric blender in the percentage ratio as presented in Table (1).

Table (1): Formulation of corn/quinoa flour blends:-

Treatments	Flour blends
T1 (Control)	100% YCF
T2	80% YCF+ 20% QF
T3	60% YCF+ 40% QF
T4	40% YCF+ 60% QF
T5	20% YCF+ 80% QF
T6	100% QF

2.2.3. Preparation of corn-quinoa flakes

Flakes samples (control and corn-quinoa flakes) were prepared according to the method of Leusner **(23)**. Flour blends were mixed with water until the dough formed (moisture content 22 to 35%); flakes dough that had been formed was then flattened using a roller (thickness 0.38 – 0.63 mm). After that, it was cut into flakes (3.5 –6.5 g) and dried using an electric oven at 210±2^{o}C for 2-3 min. All obtained flake samples are then stored in plastic bags at room temperature for further analysis.

2. 2.4. Chemical analysis

Proximate chemical composition

Moisture, crude protein, ether extract, crude fiber, and ash were determined in corn-quinoa flakes samples according to AOAC **(24)**. Carbohydrates were calculated by difference as follows: Carbohydrates (%) = 100 - (% protein + % fat + % crude fiber + % ash).

Determination of amino acids profile

Amino acids of corn-quinoa flake samples were determined according to the method described in AOAC **(25)** using the automatic amino acid analyzer Model (Beckman 7300/G 300). Amino acid score (AAS) was calculated according to FAO/WHO **(26).** As follows: AAS% =

$$\frac{\text{mg of amino acid in 1g tested protein}}{\text{mg of amino acid in reference protein}} x\,100$$

Determination of minerals content

Calcium (Ca), potassium (K), and magnesium (Mg) were determined according to the method of Jackson **(27)**. Phosphorus (P) was determined according to the procedure described by Tan **(28)**. Iron (Fe) and zinc (Zn) were determined using Atomic Absorption GBC 909 AA, as described in AOAC **(25)**.

Determination of total phenolic content

The total amount of phenolic compounds in corn-quinoa flakes samples was determined in the extract flour samples by the Folin-Ciocalteu method. Gallic acid was used as a standard, expressed in mg of gallic acid equivalents (GAE) per 100 gram dry weight according to **(29).**

Determination of total flavonoids content

The total amount of flavonoid compounds in corn-quinoa flakes samples was analyzed according to the method described **(30).** The total flavonoids content was expressed as mg rutin equivalents/100 g (dry weight basis).

Determination of antioxidant activity

The antioxidant activity of corn-quinoa flake samples was determined according to 2-2-diphenyl-1-picrylhydrazyl (DPPH). The DPPH method is based on the destruction of DPPH by the antioxidant

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substances present in the sample according to the following equation by Beta et al. **(31):**

$$\% \text{ Inhibition} = [(Abs_{control} - Abs_{samples}) / Abs_{control}] \times 100.$$

2. 2.5. Determination of color quality of corn-quinoa flakes

The color of corn-quinoa flake samples was determined by measuring L (whiteness/ darkness), a (redness/greenness), and b (yellowness/blueness) parameters using Hunter lab colorimeter according to the method of Akesowan **(32).**

2. 2.6. Sensory evaluation

Sensory evaluation of corn-quinoa flakes samples was determined using twenty members from Flavor and Aroma Chemistry Department, Food Industries and Nutrition Division, National Research Centre. Each panellist was asked to assign scores 0–10 for appearance, color, taste, odour, texture, and overall acceptability. A sensory score of 5 or above was deemed acceptable, and a score below five was considered unacceptable **(33).**

2. 2.7. Statistical analysis

The results obtained were statistically analyzed using one-way analysis of variance (ANOVA) followed by Duncan's test according to the procedure of **(34)** using SPSS version 20.0 software computer program.

4. Results and Discussion

4. 1. Chemical composition of Corn-Quinoa flakes

The chemical composition of prepared corn-quinoa flakes listed in Table (2). As shown in the obtained results (Table 2), it could be noticed that substitution of corn-quinoa flakes produced from YCF substituted by different levels (20, 40, 60, 80, and 100%) of QF caused a significant increase *($P<0.05$)* in crude protein (10.55, 12.07, 13.42, 14.85 and 16.35%, respectively), ether extract (2.87, 3.71, 4.34, 5.02 and 5.90%, respectively), crude fiber (1.48, 1.75, 1.95, 2.15 and 2.36%, respectively) and ash (1.54, 2.03, 2.43, 2.85 and 3.27%, respectively) when compared with control sample prepared from 100% YCF (9.22, 2.29, 1.26 and 1.14%, respectively). On the other hand, the carbohydrates content decreased significantly *($P<0.05$)* as the substitution levels increased from 20% to 100% in produced flakes, which reached (72.12%) in flakes containing 100% QF compared with (86.09%) control samples containing 100% YCF.

These results are following those obtained by Rosell et al. **(22)**, Khalil et al. **(35)**, and El-Sohaimy et al. **(36).** They reported gradual increases in protein, fat, fiber, and ash content, parallel to the rise in the substitution level of quinoa flour in bakery products such as pan bread and cookies. In addition, Quinoa seeds are a complete food with high nutritional value **(37)** due mainly to their high content of good-quality protein **(9)**.

(2): Chemical composition (g/100g) of flakes produced from yellow corn and quinoa flour(on a dry weight basis)

Samples	Moisture	Crude Protein	Ether Extract	Crude Fiber	Ash	Total carbohydrates•
Control (100%YCF)	5.96 ±0.04[f]	9.22 ±0.33[f]	2.29 ±0.13[f]	1.26 ±0.06[f]	1.14 ±0.02[f]	86.09 ±0.15[a]
80% YCF +20% QF	6.08 ±0.02[e]	10.55 ±0.24[e]	2.87 ±0.08[e]	1.48 ±0.04[e]	1.54 ±0.06[e]	83.56 ±0.24[b]
60% YCF +40% QF	6.13 ±0.06[d]	12.07 ±0.16[d]	3.71 ±0.16[d]	1.75 ±0.04[d]	2.03 ±0.06[d]	80.44 ±0.10[c]
40% YCF +60% QF	6.24 ±0.02[c]	13.42 ±0.24[c]	4.34 ±0.05[c]	1.95 ±0.03[c]	2.43 ±0.04[c]	77.86 ±0.28[d]
20% YCF +80% QF	6.39 ±0.05[b]	14.85 ±0.12[b]	5.02 ±0.09[b]	2.15 ±0.02[b]	2.85 ±0.02[b]	75.13 ±0.50[e]
100% QF	6.57 ±0.08[a]	16.35 ±0.09[a]	5.90 ±0.06[a]	2.36 ±0.04[a]	3.27 ±0.03[a]	72.12 ±0.33[f]

Means ± standard deviations; the means within the same column having different superscripts are significantly varied *(P<0.05)* . ; YCF: Yellow Corn Flour; QF: Quinoa Flour; • Total Carbohydrates were calculated by difference.

4. 2. Essential amino acids content of Corn-Quinoa flakes

The nutritional quality protein of Corn-Quinoa flakes samples was determined according to the reference protein pattern of FAO/WHO (**26**) and listed in Table (3). From the obtained results in Table (3), it could be shown that the essential amino acids of produced corn-quinoa flakes were significantly increased *(P<0.05)* in essential amino acids (Histidine, Lysine, Isoleucine, Threonine, and Methionine+Cystein by increasing levels of added QF from (20% to 100%) in corn-quinoa flakes samples, it was presented (2.01 to 3.28, 3.13 to 5.83, 4.22 to 5.15, 3.49 to 4.86 and 3.34 to 6.16 g/100g protein, respectively) when compared with the control sample (1.69, 2.41, 3.99, 3.21 and 2.62 g/100g protein, respectively).

Also, As given in Table (3), it could be observed that the (%) amino acids score of Corn-Quinoa flakes samples recorded a significant increase *(P<0.05)* by replacement levels of QF (20, 40, 60, 80, and 100%), it was presented (99.62, 105.47, 111.18, 116.89 and 122.88 %, respectively) as compared with corn-quinoa flakes control sample (93.82%). This increase in essential amino acids of Corn-Quinoa flakes samples may be due to the highest content of QF from essential Amino acids: Histidine, Lysine, Valine, Leucine Isoleucine, Threonine, Methionine + Cysteine, and Phenylalanine + Tyrosine (3.16, 5.77, 4.90, 7.05, 5.03, 4.14, 5.13 and 7.31 g/100g of QF) as shown in Table (3). This result was accordance with Repo-Carrasco et al. (**9**), El-Sohaimy et al. (**36**), and Demir and Bilgicll(**38**).

Table (3): Essential amino acids content (g/100g protein) of QF and flakes produced from corn and quinoa flour as compared by the provisional amino acid pattern of FAO/WHO (1973).

Amino acids g/100g protein	QF g/100g protein	Control ▲	Replacement levels of QF 20%	40%	60%	80%	100%	FAO/WHO g/100g protein
Histidine	3.16± 0.08	1.69*± 0.05^{f}	2.01± 0.08^{e}	2.35± 0.09^{d}	2.67± 0.07^{c}	2.95± 0.10^{b}	3.28± 0.08^{a}	1.90
Lysine	5.77± 0.10	2.41*± 0.08^{f}	3.13*± 0.06^{e}	3.79*± 0.08^{d}	4.43*± 0.10^{c}	5.15*± 0.06^{b}	5.83± 0.12^{a}	5.5
Valine	4.70± 0.09	4.70± 0.10^{a}	4.72± 0.12^{a}	4.73± 0.10^{a}	4.75± 0.12^{a}	4.77± 0.09^{a}	4.80± 0.06^{a}	3.88
Leucine	7.75± 0.07	8.55± 0.12^{a}	8.43± 0.06^{a}	8.32± 0.08^{ab}	8.19± 0.10^{ab}	8.06± 0.08^{b}	7.96± 0.10^{b}	7.00
Isoleucine	5.03± 0.08	3.99*± 0.04^{f}	4.22± 0.06^{e}	4.46± 0.12^{d}	4.70± 0.08^{c}	4.91± 0.10^{b}	5.15± 0.12^{a}	4.00
Threonine	4.54± 0.09	3.21*± 0.06^{f}	3.49*± 0.12^{e}	3.80*± 0.08^{d}	4.11± 0.10^{c}	4.47± 0.09^{b}	4.86± 0.08^{a}	4.00
Methionine +Cysteine	5.93± 0.08	2.62*± 0.05^{f}	3.34*± 0.08^{e}	4.07± 0.12^{d}	4.81± 0.08^{c}	5.50± 0.09^{b}	6.16± 0.10^{a}	3.50
Phenylalanine + Tyrosine	6.31± 0.09	7.15± 0.10^{a}	7.10± 0.12^{a}	7.06± 0.10^{a}	7.01± 0.08^{a}	6.95± 0.10^{a}	6.91± 0.12^{a}	6.80
Total Essential Amino acids	*43.19± 0.12*	*34.32*± 0.15^{f}*	*36.44* ± 0.17^{e}*	*38.58± 0.12^{d}*	*40.67± 0.10^{c}*	*42.76± 0.16^{b}*	*44.95± 0.18^{a}*	36.58
Amino acid Score (%)	*118.07*	*93.82*	*99.62*	*105.47*	*111.18*	*116.89*	*122.88*	100%

Means ± standard deviations; the means within the same row having different superscripts are significantly varied *(P<0.05)* . ;
▲ Control sample prepared from 100% yellow corn flour; QF: Quinoa Flour. *: Limiting amino acids. - Tryptophan was not determined

4.3. Minerals content of Corn-Quinoa flakes

The mineral content of corn-quinoa flakes samples was determined, and results were presented in Table (4). Obtained data in Table (4) indicated that the contents of Ca, P, Mg, K, Fe, and Zn were increased significantly *(P<0.05)* with increasing the substitution levels of quinoa flour (QF) from 20% to 100% in all the tested samples when compared with control. In this concern, flakes containing 100% QF exhibited higher content of Ca (118.74 mg/100g), P (405.42 mg/100g), Mg (199.08 mg/100g), K (795.58 mg/100g), Fe (8.44 mg/100g) and Zn (4.62 mg/100g) than the control flakes made from 100% YCF. This increase in the mineral content of produced flakes may be attributed to the high concentration of these minerals in quinoa seeds flour (**39** and **40).**

These results agree with Khalil et al. (35) found that incorporation of quinoa flour with corn flour at levels 25, 50, 75 and 100% caused an increase in K, Ca, P, Mg, Fe, Mg, Na and Na and Zn content of produced free gluten pan bread. Also, **(41)** indicated that the mineral content of corn flakes was increased with increasing additional levels of peanut flour up to 30%.

Table (4): Minerals content (mg/100g sample) of corn-quinoa flakes samples produced from yellow corn and quinoa flours (on a dry weight basis).

Samples	Minerals content (mg/100g)					
	Ca	P	Mg	K	Fe	Zn
Control (100% YCF)	48.74±0.69[f]	231.11±2.71[f]	125.55±1.17[f]	320.94±2.75[f]	3.09±0.02[f]	1.45±0.02[f]
80% YCF +20% QF	63.00±0.84[e]	266.46±1.53[e]	139.61±0.66[e]	411.01±3.92[e]	4.15±0.03[e]	2.02±0.07[e]
60% YCF +40% QF	77.19±0.82[d]	300.55±2.68[d]	155.60±2.28[d]	520.41±1.15[d]	5.27±0.01[d]	2.79±0.03[d]
40% YCF +60% QF	92.19±1.88[c]	335.80±3.71[c]	168.67±1.90[c]	609.76±2.10[c]	6.31±0.02[c]	3.41±0.03[c]
20% YCF +80% QF	103.71±2.20[b]	372.34±2.91[b]	183.55±2.44[b]	701.91±3.40[b]	7.37±0.04[b]	4.05±0.04[b]
100% QF	118.74±1.97[a]	405.42±2.95[a]	199.08±2.61[a]	795.58±3.28[a]	8.44±0.01[a]	4.62±0.02[a]

Means ± standard deviations; the means within the same column having different superscripts are significantly varied *(P<0.05)*; YCF: Yellow Corn Flour; QF: Quinoa Flour.

4.4. Phenolics, flavonoids content, and the antioxidant activity of developed corn-quinoa flakes

The means value of total phenolics (mg GAE/100 g), total flavonoids (mg rutin /100g), and antioxidant activity by DPPH (on a dry weight basis) of corn flakes produced from different levels of yellow corn flour (YCF) and quinoa flour (QF) were determined and are represented in Table (5). From the obtained data, as illustrated in Table (5), it could be seen that the total content of phenolic and flavonoid compounds and antioxidant activity of prepared flakes were increased significantly *(p<0.05)* by increasing of QF ratio in the flakes formulation. Total phenolics and total flavonoids content were increased from (128.15 and 7.29 mg/100g) in flakes enriched with 20% QF to (162.10 and 10.82 mg/kg) in flakes containing 100% QF as compared with control samples prepared from 100% YCF, which recorded 119.45 and 6.35 mg/100g); respectively. In this concern, the antioxidant activity of produced flakes increased significantly (p<0.05) from 20.89% in flakes samples containing 20% QF to reach 36.52 % in flakes made from 100% QF compared with control samples which recorded 16.95%.This increase in the content of total phenolics, total flavonoids, and antioxidant activity values of the corn flakes enriched with quinoa flour is most likely attributable to the fact that quinoa seeds flour is very rich in phenolics compounds and antioxidant capacity (**42** and **43)**. Several studies have noted significant increases in antioxidant activity and total phenolic content following the addition of quinoa flour in bakery products (**35, 47, and 38)**.

Table (5): Total phenolics, total flavonoids content, and antioxidant activity of corn-quinoa flakes samples produced from corn and quinoa flour

Samples	Total Phenolics (mg GAE/100g)	Total Flavonoids (mg rutin/100g)	Antioxidant Activity (%)
Control (100% YCF)	119.45 ± 1.12[f]	6.35 ± 0.25[f]	16.95 ± 0.23[f]
80% YCF +20% QF	128.15 ± 0.98[e]	7.29 ± 0.20[e]	20.89 ± 0.92[e]
60% YCF +40% QF	137.10 ± 0.87[d]	8.16 ± 0.57[d]	24.70 ± 0.59[d]
40% YCF +60% QF	145.92 ± 1.02[c]	9.06 ± 0.35[c]	28. 65 ± 0.65[c]
20% YCF +80% QF	153.89 ± 0.55[b]	9.95 ± 0.08[b]	32.62 ± 0.20[b]
100% QF	162.10 ± 0.68[a]	10.82 ± 0.55[a]	36.52 ± 0.45[a]

Means ± standard deviations; the means within the same column having different superscripts are significantly varied *(P<0.05)* . ; YCF: Yellow corn Flour; QF: Quinoa Flour.

4. 5. Color quality of Corn-Quinoa flakes

Color values of control flakes prepared from 100% YCF and flakes samples containing quinoa flour (QF) at substitution levels of 20, 40, 60, 80, and 100% were determined, and results are summarized in Table (6). *L** (light/dark) and *b** (blue/yellow) values of produced flakes decreased gradually with the substitution amount from 20 to 100% quinoa flour compared with control corn flakes. While, *a** (green/red) values increased significantly with increasing the replacement levels of quinoa flour compared with control. These changes in the L*, a* and b* values of produced corn-quinoa flakes may be attributed to Millard reactions during baking **(44).** Similar results have been reported by Malik et al. (**41**), Priyanka et al. (**45**), and Dewidar et al. (**46**).

Table (6): Color quality of RTE-flakes produced from yellow corn and quinoa flour

Samples	Parameter		
	L^*	a^*	b^*
Control (100% YCF)	67.46± 1.23^a	16.59± 0.53^e	24.70± 0.86^a
80% YCF +20% QF	67.02 ± 1.10^a	16.84± 0.67^e	24.96± 0.65^a
60% YCF +40% QF	65.18± 0.26^b	18.35± 1.14^d	23.16± 0.27^b
40% YCF +60% QF	64.06± 0.12^b	21.46± 1.08^c	21.55± 1.10^c
20% YCF +80% QF	62.92± 0.08b^c	23.20± 0.83^b	19.87± 0.29^d
100% QF	58.77± 0.51^d	24.89± 0.50^a	18.09± 0.50^e

Means ± standard deviations; the means within the same column having different superscripts are significantly varied *(P<0.05)*
YCF: Yellow corn Flour; QF: Quinoa Flour.
L^* degree of lightness; a^* degree of redness; b^* degree of yellowness; ΔE is a single value that considers the differences between the *L*, *a*, and *b* of the sample and standard.

4. 6. Organoleptic characteristics of Corn-Quinoa flakes

The sensory characteristics of the flakes prepared from yellow corn (YCF) and quinoa flour (QF) were evaluated, and the results are presented in Table (7). The organoleptic attributes (appearance, color, taste, odor, texture, and overall acceptability) of corn-quinoa flakes containing different levels of QF were significantly affected. The overall acceptability of flakes was determined by taking average of all the value pertaining to appearance, color, taste, texture and odor. It was found that corn flakes containing 20 and 40% of QF were found to secure maximum score, while the minimum score was found in samples containing 100% QF compared with the control sample. Corn-quinoa flakes samples containing 20 and 40 % QF showed no significant differences in all their sensory properties and were as acceptable as compared to control flakes prepared from 100% YCF, while further increase in substituted levels results in drastic reduction in most sensory properties. These results are approximately similar to those reported by Khalil et al. (35), Priyanka et al. (45), and El-Sebeay et al. (47).

Table (7): Organoleptic properties of corn-quinoa flakes produced from yellow corn and quinoa flour

Samples	Appearance	Color	Taste	Odor	Texture	Overall acceptability
Control (100% YCF)	9.55±0.12^a	9.40±0.03^a	8.90±0.06^a	9.00±0.02^a	8.50±0.91^a	8.10±0.02^a
80% YCF +20% QF	9.50±0.04^a	9.38±0.09^a	8.87±0.10^a	9.10±0.08^a	8.55±0.07^a	8.00±0.16^a
60% YCF +40% QF	9.53±0.08^a	9.39±0.12^a	8.20±0.02^b	9.00±0.02^a	8.10±0.02^b	8.00±0.05^a
40% YCF +60% QF	8.50±0.13^b	8.76±0.08^b	7.85±0.08^c	9.05±0.05^b	7.80±0.45^c	7.60±0.02^b
20% YCF +80% QF	8.24±0.02^c	8.19±0.02^c	7.46±0.03^d	8.70±0.09^c	7.25±0.13^d	7.55±0.08^b
100% QF	7.95±0.05^d	8.00±0.03d	7.10±0.05^e	8.15±0.04^d	7.00±0.09^e	7.00±0.12^c

Means ± standard deviations; the means within the same column having different superscripts are significantly varied *(P<0.05)* . ; YCF: yellow corn flour; QF: Quinoa Flour.

5. Conclusion

In this research, incorporating quinoa flour into corn flakes significantly increased crud protein, ether extract, crud fiber, and ash content. Also, significant improvements were observed in minerals, amino acids contents and some phytochemicals, including phenolics, flavonoids, and antioxidant activities of produced corn-quinoa flakes. Color values showed no significant changes with replacing yellow corn flour with quinoa flour up to 40%. Corn flakes enriched with quinoa flour up to 40% were found to be the most accepted samples from the sensory point of view compared to the control samples. Overall, it could be recommended that the feasibility utilization of quinoa seeds flour in bakery products and other food products is an excellent source of essential amino acids and other nutrients.

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Conflict of Interests

The authors declare no conflict of interest, financial or otherwise

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