Journal of Food and Dairy Sciences

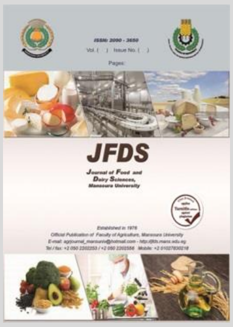
Journal homepage: www.jfds.mans.edu.eg
Available online at: www.jfds.journals.ekb.eg

Preparation and Evaluation of Healthy Crackers by Using Flour Mixes of Different Types of Cereal

Mona H. Hassan[1;] M. A. Salem[2] and Mona M. Doweidar[1*]

[1]Bread & Pastries Res. Dept., Food Tech. Res. Institute, Agric. Res. Center, Egypt.
[2]Food Science and Technology, Dept., - Faculty of Agriculture - Tanta University, Egypt.

Cross Mark



ABSTRACT

This study aims to produce healthy crackers by using mixes of wheat flour 72% extraction (W.F)with flour of grains (whole meal) such as maize flour (M.F), naked barley flour (B.F), quinoa flour (Q.F) and proso millet flour (P.F). Results showed that Q.F was highest in protein, fat and ash. While P.F records a high percentage of crude fiber. Barley Flour showed the highest content in phosphorous. P.F showed the highest content in sodium and zinc. Beta-carotene was highest in M.F, while thiamine was highest content in P.M. Barley Flour is highest in niacin and quinoa flour recorded highest content in vitamin E, also it recorded the highest percentage of total essential amino acids, followed by M.F. The results showed that B.F was highest in antioxidants, while total phenols were highest in Q.F and M.F was higher in total flavonoids content. Crackers made from the first mixture were the highest content of crude protein, fat, ash, carbohydrates and mineral (calcium, iron, potassium and magnesium), while the crackers of the second mixture were the highest content of vitamin B1and B3. The content of beta-carotene was the highest in the third mixture, while crackers of the fourth mixture were higher in riboflavin and ascorbic acid content compared to control crackers. All types of crackers were the highest in contribute of most of Recommended Dietary Allowances for a studied previous nutrient for children compared with control crackers. So it could be recommended to use investigated grains in bakery products to obtain healthy bakery products.

Keywords: crackers, maize flour, naked barley flour, quinoa flour and proso millet flour nutritional value.

INTRODUCTION

Recently functional food sciences have a great responsibility for improving health status in developed countries. On the other hand, people around the world looking for how to become healthier to avoid the increasing in healthcare costs and rising the average life expectancy (Martirosyan and Singh, 2015).

Phytochemicals are biologically active and naturally occurring chemical compounds found in plants. The most common phytochemicals are the polyphenolic which consist of flavonoids and phenolic acids (Puupponen-Pimiä *et al.*, 2005). Bioactive compounds are essential and nonessential compounds e.g., vitamins or polyphenols, which occur in nature, are considered as a part of the food chain and can be shown to have an effect on human health (Biesiekierski *et al.*, 2013). Nature has been a source of medicinal treatments for thousands of years, functional foods continue to play an essential role in the primary health care of 80% of the world's under developed and developing countries (Eidi *et al.*, 2007).

Humans currently derive 30% to 70% of their daily energy from cereal-based foods, indicating that innovation of grain or grain like functional foods plays a role in the conversion of agricultural crops to consumables (Poutanen *et al.*, 2014).The increased interest in cereals has coincided with an increase in the prevalence of obesity and increases in chronic diseases such as diabetes, hypercholesterolemia, cardiovascular disease and other diseases (Fung *et al.*, 2002 and Truswell, 2002). Studies have shown dietary fiber to have many health benefits. As cereals is an excellent source of dietary fiber and in particular the functional food ingredient beta-glucan, consumers have become more inclined to increase their utilization of cereals as a source of food. The reviews studied showed that the use of barley and maize beta-glucan in foods and the potential scope for their increased use in foods in the future (Sullivan *et al.*, 2010).

The edible seeds of quinoa (*Chenopodium quinoa* Willd.), are small, round and flat. Seed colors can range from white to grey and black, or can be yellow and red. Because of its high nutritional characteristics, United Nations General Assembly has therefore declared 2013 that quinoa is a rich source of protein (12-16.5%) with protein quality equivalent to that of casein. In addition to quinoa is gluten free rich in bioactive compounds like antioxidants, polyphenols, flavonoids, vitamins and minerals that impart various health benefiting characteristics to this grain. Moreover products prepared with different processing techniques have various health benefits and to be effective in cases of obesity, cardiovascular diseases, hypertension, and celiac disease (Vega-Galvez *et al.*, 2010 and Srujana *et al.*, 2019).

Corn seeds (*Zea Mays*) are used as a nutritional source for humans. All parts of corn plant are good source of a variety of bioactive phytochemical compounds which possess antioxidant potential. The principal phytochemicals present in corn seed and corn silk include polyphenols, phenolic acids, flavonoids, anthocyanins, glycosides, carotenoids, and polysaccharides of biological importance, reducing compounds and some water-soluble vitamins. The presence of these phytochemicals makes corn a medicinal plant which shows various biological activities particularly the antioxidant, antimicrobial, antidiabetic, anti-obesity, antiproliferative,

[*] Corresponding author.
E-mail address: mona.doweidar@live.com
DOI: 10.21608/jfds.2021.153276

hepatoprotective, cardioprotectiv and renal-protective activities. On the account of its high antioxidant potential, all parts of corn plant can be used for the management of oxidative stress and the treatment of various diseases (Nawaz *et al.*, 2018).

Barley grains (*Hordeum vulgare, L*) contain much greater amounts of phenolic compounds (0.2–0.4%) than other cereal grains. The main flavanols found are the catechins, procyanidin B3, and prodelphinidin B3. From analysis of sixteen varities of barley, the total amount of flavanols ranged from 325 to 527 µg/g of fresh weight of barley flour, with no associations between proanthocyanidin levels and different barley types (Holtekjolen *et al*., 2006). Barley contains relatively high concentrations of the mixed-linkage (1-3) (1-4) β–D glucans (β-glucan). Although β-glucan occurs in all cereals, its concentration is highest in oats and barley with values ranging from 2% - 16% (Wood, 2007). The barley and other cereal, rich in functional ingredients are gaining popularity amongst those who are accustomed to softer cereals like wheat and rice because of the presence of dietary fiber, beneficial in various degenerative diseases (Dewettinck *et al*., 2008).

Proso millet (*Panicum miliaceum*) is the oldest cultivated millet crop and is often cultivated in harsh conditions as an alternative to maize because of their better adaptability to arid and barren lands than most other crops. It is superior to rice and wheat, because it provides protein, mineral and vitamins to the poor where the need for such nutrients is in high demand (Taylor and Emmambux, 2008). Proso millet is rich in nutraceuticals like dietary fiber, omega-3 fatty acids, phenolics, and flavonoids which play a potential role in treatment of degenerative diseases and metabolic disorder by improving cholesterol metabolism, preventing the oxidative damage of body tissues and DNA as well as in the regulation of blood sugar (Thathola *et al.*, 2011 and Bora *et al*., 2018). Phytochemicals from proso millets have increased interest due to their antioxidant, antimicrobial and anti-carcinogenic effects as well as other potential health benefits (Awika *et al.*, 2003 and Kim *et al.*, 2010).

The aim of this study is to formulate novel crackers by using flour mixes of different types of cereal to enriched products, besides having good nutritive value, show new dimensions of health benefits.

MATERIALS AND METHODS

Materials:-

-Wheat flour 72 % extraction rate (*Triticum aestivum, L.*) was obtained from the North Cairo Flour Mills Company, Egypt.

-Hull-less (naked) barley grains (*Hordeum vulgare, L*) *variety "Giza 126" was* obtained from Crops Research Institute, Agric. Research, Center, Giza, Egypt. They were milled using Hummer mill to obtain whole meal flour.

-Quinoa seeds (*Chenopodium quinoa Willd.*), was obtained from Crop Intensification Research Department (CIRD), Field Crops Research Institute (FCRI), Agricultural Research Center (ARC) as a novel crop for agriculture in Egypt.

-Millet (*Panicum miliaceum*) and Maize flour (*Zea Mays*) were obtained from Crops Research Institute, Agric. Research, Center, Kafr-Elsheikh, Egypt.

- Other materials: Salt, sugar, dry yeast, were purchased from local market Kafer El-Shakh city, Egypt.

Methods:-

Preparation of quinoa and hull-less barley flour:

Quinoa flour was prepared according to Al- Shehry (2016). Quinoa seeds were cleaned and washed many times with cold water to remove saponine until there was no more foam in the washing water and then dried on a plate in an air oven at 50°C. The dried seeds were ground to find powder in an electric grinder stainless using laboratorial disc mill into flour that could pass through a 60mesh screen. Also hull-less barley were milled using Hummer mill to pass through a 60 mesh sieve to obtain whole milled flour. Fine quinoa flour and barley whole milled flour were packaged into polyethylene bags and stored in deep freezer (-18°C) until using.

Preparation of proso millet:

Millet seeds were cleaned and separated from the aromatic skin, then blended to reduce the size. Millet flour then sieved with 80 mesh sieve (Anandito *et al.*, 2019).Then whole milled flour proso millet was packaged into polyethylene bags and stored at -18°C until using.

Preparation of maize flour:

The maize was cleaned from extraneous particles, flour was obtained by sieving through a 250 mm laboratory test sieve after sorting to remove foreign matters and broken grains were winnowed, milled into flour using attrition mill and sieved using 250 mm laboratory test sieve to obtain fine flour. The flours were packaged into polyethylene bags and stored at -18°C until using (Gebrezgi, 2019).

Treatments:

Pretest experiment has been carried out to determine the best mix ratio of suggested raw materials are chosen for this study as shown following in Table (A).

Table A. The blends used for preparing crackers.

Treat.		Blends composition	
Control		100 % Wheat flour 72% extraction rates	W
Single mixes	1	30 %wheat flour +70% barley flour.	B
	2	30 %wheat flour +70% quinoa flour.	Q
	3	30 %wheat flour +70% proso millet flour.	P
	4	30 %wheat flour +70% maize flour.	M
Duple mixes	5	30 %wheat flour +35% maize flour + 35% barley flour.	MB
	6	30 %wheat flour +35% quinoa flour + 35% barley flour.	QB
	7	30 %wheat flour +35% maize flour + 35% quinoa flour.	MQ
	8	30 %wheat flour +35% proso millet flour + 35% barley flour.	PB
	9	30 %wheat flour +35% proso millet flour + 35% maize flour.	PM
	10	30 %wheat flour +35% proso millet flour + 35% quinoa flour.	PQ
Multi mixes	11	30 %wheat flour+20% barley flour +25% maize flour+ 25% proso millet flour.	T1
	12	30 % wheat flour + 20% maize flour + 25% barley flour+ 25% proso millet flour.	T2
	13	30 % wheat flour +20% quinoa flour + 25% barley flour+ 25% proso millet flour.	T3
	14	30 % wheat flour + 20% proso millet flour +25% barley flour + 25% quinoa flour.	T4
	15	20 %wheat flour +20% barley flour +20% maize flour+ 20% proso millet flour + 20% quinoa flour.	T5

Preparation of crackers:

Crackers were made according to the method described in Bose and shams- Ud- Din (2010). Basic formulations used for preparation of crackers are outlined in Table (B). The pre weighted ingredients (flour, powder milk, salt, lemon salt, baking powder) were mixed. Corn oil was added into the dry ingredients. Water was added accurately to form smooth dough, and the resulted dough was let to rest for 5 min. The dough kneaded and rolled to a uniform thickness of 3 mm. The crackers were cut out. Then the crackers were baked at 200^{0}C for 10-15 minutes and cooled at room temperature for about 1 hr. before sensory evaluation.

Table B. The basic formula used in the preparation of crackers was followed as:

Ingredients	Quantity(g)
Flour	100
Powder milk	1
Corn oil	10
Salt	2
Lemon salt	0.4
Baking powder	3

Sensory evaluation of crackers:

Crackers produced using suggested blends were evaluated for their sensory characteristics by ten panelists from the staff of Bread and Pastry, Research Dep., Agr. Res. Center, Giza. The scoring scheme was established as mentioned by Omobuwajo (2003) as follows; taste (10), color of crust (10), flavor (10) Crispness (10), general appearance (10). The overall score 50 degrees.

Chemical analysis:

-Moisture, protein, ether extract and ash content were determined according to the method described in A.O.A.C (2012).

-Crude fiber content was determined as described by Kirk and Sawer (1991).

-Available carbohydrates content of sample was calculated by difference as mentioned by Fraser and Holmes (1959).

Available Carbohydrates (on dry weight basis) =100– (% Protein + % Fat +% Ash +% Crude fiber).

The energy value of cracker was calculated according to Lawrence (1965) using the following equation:

Total energy (K.cal/100g) = 4 (% carbohydrate +% protein) + 9 % fat

-Minerals content, i.e., Fe, Zn, Ca, and Mg were determined by Atomic Absorption Spectrophotometer (Model 3300, Perking Elmer, England) (Lanyon and Healed, 1982).

-Phosphorus content was determined by ascorbic acid technique using the colorimetric method that described by Murphy and Riley (1962). Potassium and sodium contents of samples were estimated using flame photometer as given by Pearson (1976).

-Vitamins content: Thiamin, riboflavin, niacin, ascorbic acid, β-carotene and tocopherol contents of dry samples were determined using High Performance liquid chromatography (HPLC). Model 7300 Beckman, according to the method described in A.O.A.C (2012) at Central Laboratory for Food and Feed, Agric. Res. Center, Egypt.

-Amino acids content were determined according to the method of Sadasivam and Manickam (1992) by using Amino Acid Analyzer (Beckman Amino Acid Analyzer, Model 119 CL). Tyrptophan content of samples was determined calorimetrically in the alkalin hydrolyzate following the method of Miller (1967).

-Total flavonoids in sample extracts were determined according to the method described by Zhishen *et al.* (1999).

- The antioxidant activity of samples was determined by the 2, 2'-Diphenyl-1-picrylhydrazyl (DPPH) according to the method described by Brand-Williams *et al.* (1995).

-Total phenolic content in sample extracts was determined according to the method described by Mazza *et al.*(1999), with some modifications as described by Radovanovic and Radovanovic (2010).

- Recommended dietary allowances % (RDA):

Recommended dietary allowances from the Dietary Reference Intakes according to Food and Nutrition Board as reported by National Academy of Science (2004).

$$\% \text{ RDA} = \frac{\text{Value of nutrient in sample of crackers} \times 100}{\text{RDA for the same nutrient.}}$$

Statistical Analysis:

Data were analyzed using a completely randomized design (SAS, 1985) when a significant main effect was detected, the means were separated with the student-Newman-Keuls test. Differences between treatments of (P≤0.01) were considered significant.

RESULTS AND DISCUSSION

Chemical composition of used cereals:

The chemical compositions of some cereals under investigation were found in Table (1). It could be noticed that the moisture content of the different raw materials did not show any significant differences between and flours was found to vary between 9.9 % for proso millet flour and 12% for hulls barley flour compared with 10.5% for wheat flour (72% extraction). Protein of wheat flour (12.8%) was significant higher than protein of maize flour (10.8%) but was significant lower than protein of quinoa flours (16.7%). This result was near to Chandra *et al.*(2016) whose reported that protein of maize, barley and proso millet were (12.1, 11.5 and 11%) respectively. On the other hand ether extract of wheat flour was (1.5%) and significant lowest followed by barley, proso millet, maize and quinoa flours (2.69, 3.3, 4.6 and 7.1, respectively). This result were fairly close Yaseen *et al. (*2010) whose reported that ether extract of wheat flour and maize flour was (1.7and 4.5%). As for fiber of proso millet flour was significant highest content(14.8) as compared with all of wheat, maize, barley and quinoa flours (0.6, 1.9, 4.64 and 3.7) respectively. This result agreed with Devi *et al.* (2014) who reported that proso millet was rich in dietary fiber (18%) and protein (6%–13%). Quinoa flour was significant highest content of ash (3.8) but barley flour content was near proso millet, while wheat flour (0.5) was the lowest followed by maize flour (1.10%) in ash content. Furthermore, available carbohydrate of wheat flour (84.5) wad near to maize flour content but significant higher than proso millet, quinoa and barley (66.30, 68.70 and 77.33). This result agreed with Mlyneková *et al.*(2014) whose reported that ash of quinoa flour was very high (3.8), barley and proso millet flours was lower (2.2 and 2.0). From the previous resulted concluded that quinoa flour is rich in protein, ether extract and ash from other grains. This result agreed with (Nowak *et al*., 2015) who reported that quinoa flour was rich in protein and ether extract (15.7 and 7.6, respectively). While the percentage of protein in proso millet and hulls barley flour was fairly close, the data suggest that these grains are a good source of ash, crude fiber which is nutritionally important. So data indicates that these cereals are considered a good source of ash, crude fiber and total carbohydrates which are important from the nutrition

Table 1. Chemical composition of raw materials (g/100g on dry weight basis).

Constituents %	Wheat flour (72% ex.)	Maize flour	Hulls barley flour	Quinoa flour	Proso millet flour
Moisture	10.50^b ±0.29	10.20^b±0.12	12^a±0.20	11.50^a±0.16	9.90^b±0.31
Crude protein	12.80^b ±0.28	10.80^c±0.25	12.90^b±0.41	16.70^a±0.36	12.80^b±0.10
Ether extract	1.50^e ±0.04	4.60^b±0.27	2.69^d±0.19	7.10^a±0.04	3.30^c±0.24
Crude fiber	0.60^b ±0.18	1.90^b±0.21	4.64^b±0.26	3.70^b±0.30	14.80^a±3.22
Ash	0.50^c±0.27	1.10^c±0.26	2.45^b±0.20	3.80^a±0.29	2.80^b±0.32
*Available carbohydrates	84.40^a±0.05	81.60^a±0.38	77.32^b±0.46	68.70^c±0.59	66.30^c±3.07

Means ± standard deviations with different superscript letters in the same row are significantly different at *(P≤ 0.01)*.
***Available carbohydrates were calculated by difference.**

Minerals content of used cereals:

Humans require minerals for their normal life processes, particularly essential minerals, those necessary to support adequate growth, reproduction and health throughout the life cycle. Because they cannot be synthesized, minerals are necessarily obtained from the diet, and thus animals require a mineral intake for a long-term maintenance of body mineral reserves (Mc-Dowell, 2003). Minerals are involved in many important functions in the body, e.g. cofactors of hundreds of enzymatic reactions, bone mineralization, as well as protection of cells and lipids in biological membranes (antioxidant properties). Low intake or reduced bioavailability of minerals may lead to deficiencies, which causes serious impairment of body functions (Schlenker and Williams, 2003).

From the results presented in Table (2), it could be observed that barley flour contains higher values in phosphorus compared to wheat flour. Quinoa flour is considered as a good source for the minerals. Quinoa flour has the highest calcium, iron, potassium and magnesium content among all cereals. Meanwhile, the content of sodium and zinc were reach in proso millet than other cereals. From data in this Table observed that, iron, zinc, calcium, phosphorus and potassium contents of cereals were high. This result was harmony with those reported by Chethan and Malleshi (2007). So maize, barely, quinoa and proso millet flour consider rich in minerals. The importance of these minerals could be attributed to their physiological effect in human body such as calcium and phosphorus for bone and iron for blood and muscles.

Table 2. Minerals content (mg/100g on dry weight basis) of some cereals.

Minerals (mg/100g)	Wheat flour (72% ex.)	Maize Flour	Hulls barley flour	Quinoa flour	Proso millet Flour
Calcium (Ca)	35.1	9.0	31.3	85.1	22.7
Phosphorus (P)	467.7	320	489	389.5	265.7
Iron (Fe)	2.0	2.5	3.6	9.7	9.4
Potassium (K)	498.3	287.0	459.5	797.3	378.2
Sodium (Na)	19.4	17.8	7.7	13.2	35.1
Magnesium(Mg)	15.49	132	139.1	249.6	123.3
Zinc (Zn)	0.83	2.35	3.40	3.37	3.50

Vitamins contents in used cereals:

The vitamins were determined in wheat, maize, barley, quinoa and proso millet which calculated mg/100g of dry weight samples. Results in Table (3) showed that cereals are an important source of vitamins that helps to release energy from foods, promotes normal appetite, and is important in maintaining proper nervous system function (DRI,1998). Proso millet was higher in thiamine (0.52mg/100g) then wheat flour (0.47mg/100g) than other cereals but maize and hulls barley flour were recorded near results in riboflavin (0.14 and 0.15mg/100g, respectively). Also barley was higher in niacin (6.11mg/100g) than other cereals. These results are in agreement to some extent with those found by (Devi *et al*., 2014) who reported that Wheat flour was higher in thiamine (0.57mg/100g) then proso millet (0.63mg/100g). Maize and hulls barley flour were recorded near results in riboflavin (0.12, 0.14 and 0.15mg/100g, respectively). Also barley was recorded in niacin (6.11 mg/100g). On other hand quinoa was high in ascorbic acid (0.40 mg/100 g) and maize flour contain (0.12 mg/100g) ascorbic acid, while ascorbic acid was absent in other cereals. Moreover, a quinoa content of tocopherols (5.43 IU) was also found to be increased. These results are in agreement to some extent with those found by (Vega-Galvez *et al*., 2010) who reported that quinoa include vitamin A precursor β-carotene (0.39 mg/100g), thiamin (0.4 mg/100g), riboflavin (0.39 mg/100g), niacin (1.06 mg/100g) and tocopherols (3.7 to 6.0 IU). Finally maize recorded higher result in β-Carotene (IU) than other cereals. These results are in agreement to some extent with those found by (Dangeti *et al.*, 2013). So, wheat, maize, barley, quinoa and proso millet flour consider rich in vitamins .The importance of these vitamins could be attributed to their physiological effect in human body.

Table 3. Vitamins of used cereals.

Vitamins (mg/100g)	Wheat flour (72% ex.)	Maize Flour	Hulls barley flour	Quinoa flour	Proso millet Flour
β-Carotene (IU)	0.02	0.86	0.01	0.39	—
$V.B_1$(Thiamine) (mg)	0.47	0.35	0.39	0.22	0.52
$V.B_2$ (Riboflavin) (mg)	0.26	0.14	0.15	0.21	0.29
$V.B_3$ (Niacin) (mg)	5.5	3.04	6.11	0.57	4.97
V. C(Ascorbic acid) (mg)	—	0.12	—	0.40	—
V. E (Tocopherols) (IU)	1.6	2.5	2.44	5.43	—

Amino Acid Composition of Cereals used:

Protein quality is partly dependent upon its amino acid profile. The essential amino acids are very important for nutritional point of view since the cannot make and should there for supplemented in the diet (Mohamed *et al*., 2016). Amino acids composition of cereals wheat flour, maize, hulls barley, quinoa and proso millet flour are shown in Table (4). The results revealed that eleven essential amino acids were detected. In this relation, lysine, isoleucine, leucine, methionine, phenylalanine, therionine, valine and tryptophan are essential for adults, besides cysteine, tyrosine, histidine which are considered semi essential

(Davedson *et al*., 1973). The samples contained all detected essential amino acids. It could be observed that the quinoa and proso millet flours had the highest amount of essential amino acids without histidine (individual except leucine) also it was high in quinoa then maize and proso millet in total amino acid. All samples contained more amounts of non-essential amino acids than essential amino acids.

Most of E.A.A in the samples were considerably higher than need for balance (FAO/ WHO/UNU Pattern (1990)). These findings may be due to the effect of extraction rate or the variation of amino acid and types of protein in the crude extract in cereals used. However, addition of Q.F to the M.F used for preparing cracker leads to convergence ratios in their contents of sulphur containing amino acids (methionine and cystine) and this would increase the nutritive value of the food produced as reported by (Gabel-Jensen *et al.,* 2008).The nutritive value of any protein depends primarily on its capacity to satisfy the needs for essential amino acids for human being. Thus, the amino acid requirements are the logical factors by which protein quality can be measured (Bhushan, 2004).

Table 4. Amino acids composition (g/100g protein) of cereals.

Cereals Amino Acids	Wheat flour (72% ex.)	Maize flour	Hulls barley flour	Quinoa flour	Proso millet Flour	FAO/WHO/ UNU Pattern (1990)
			Essential amino acids (E.A.A)			
Histidine	2.5	2.8	2.2	3.6	2.3	1.9
Lysine	2.7	2.8	3.6	6.9	2.9	5.8
Isoleucine	3.4	3.6	3.5	4.6	4.0	2.8
Leucine	6.9	10.3	6.7	8.3	7.1	6.6
Methionine	1.7	2.1	1.8	3.1	1.9	
Cystine	1.5	1.8	1.5	1.6	1.6	
Methionine+ Cystine	3.2	3.9	3.3	4.7	3.5	2.5
Phenyl alanine	5.2	4.6	5.4	5.5	5.7	
Tyrosine	2.6	3.3	2.7	4.0	2.8	
Phenyl alanine +Tyrosine	7.8	7.9	8.1	9.5	8.5	6.3
Threonine	3.0	3.15	3.3	3.8	3.5	3.4
Valine	4.2	4.9	4.8	5.6	4.9	3.5
Tryptophan	1.3	0.7	1.7	1.5	1.9	1.1
Total (without histidine)	32.50	37.25	35	44.9	36.3	
Total E.A.A	35	40.05	37.2	48.5	38.6	
			Non-essential aminoacids (N.E.A.A)			
Arginine	4.8	4.7	4.8	10.3	4.7	
Aspartic	5.5	6.7	6.0	9.3	7.5	
Serine	5.2	5	4.3	4.9	6.2	
Glutamic	32.8	18.8	25.0	16.4	24	
Proline	13.7	8.5	11.8	4.9	7.3	
Glycine	4.1	3.9	3.5	7.6	3.7	
Alanine	3.7	6.8	3.7	4.6	7.9	
Total N.E.A.A	69.80	54.40	59.10	58	61.30	
Total A.A	104.80	94.45	96.30	106.50	99.90	

Antioxidative activity, total phenolic compounds and total flavonoid of cereals:

Results of DPPH radical scavenging activity (Antioxidative activity), total phenolic compounds and total flavonoid of different cereals given in Table (5).

Table 5. Antioxidative activity , total phenolic and total flavonoids content of different cereal flours.

parameters	Antioxidative activity % (DPPH Inhibition)	Total phenolic compounds (mg/100g) (as gallic acid)	Total flavonoid compounds (mg/100g) (ascatechein)
Wheat flour (72% ex.)	3.55	2.64	0.06
Maize flour	7.79	2.15	2.35
Hulls barley flour	11.37	2.12	0.29
Quinoa flour	5.36	4.42	1.93
Proso millet flour	6.33	3.86	2.01

It should be noticed that hulls barley flour had highest value of antioxidative activity (7.79%), results reported are in close agreement with these findings of Farooqui *et al.*(2018) who reported that antioxidant activity (%) was (14.36%) for barley flour. Then maize flour, proso millet flour and quinoa flour were (11.37- 6.33- 5.36%) respectively were higher than wheat flour. This could be attributed to phenolic acids and flavoniod content of cereals. On the other hand, total phenolic compounds of quinoa, proso millet, wheat, maize and hulls barley flour were (4.42- 3.86- 2.64- 2.15 and 2.12 mg/100g, respectively) and total flavonoid compounds of maize were (2.35 mg/100g).These results were higher than other cereals.

Sensory evaluation of produce crackers:

Sensory evaluation is considered as an important indicator of potential consumer preferences, In spite of its short comings it will remain one of the most reliable quality assessment technique for food and food products in general and for bread and bakery products in particular (Stone, 2012). So that pretest experiment has been carried out to determine the best mixes ratios of suggested raw materials are selected for this study.

Sensory evaluation of crackers produced from single mixes:

The recorded data in Table (6) showed the sensory evaluation of crackers made from wheat flour 72% as control sample and cracker samples made from 30% wheat flour supplemented with 70% of used different cereals barley, maize, quinoa and proso millet. The blend WM comparing with control and other blend samples sample had the maximum acceptance of taste, flavor, texture, crispness and overall acceptability. Also Table (6) showed that blends WM and WQ didn't show significant differences with control sample (W) in taste, flavor, color, crispness and overall acceptability. Blend WP showed less significant differences as compared with control. Moreover blend WM showed more improving in taste, flavour, crispness and overall acceptability as compared with control sample follow by blend WP then blend WB. Finally it could be conclude that blend WM had better evaluated than control sample in all characteristics except the color.

Table 6. Sensory evaluation of produce crackers supplemented with formulated of mixes cereals:

Characteristics Couscous	Taste (10)	Color (10)	Flavour (10)	Crispness (10)	overall acceptability (10)	Overall Score (50)	Acceptance
Control (100% W)	8.38^{ab}±0.69	8.81^{a}±0.59	8.50^{ab}±0.71	8.56^{ab}±0.62	8.69^{b}±0.53	42.94	G
WB (30%W+70% B)	7.69^{ab}±1.0	7.88^{ab} ±0.74	8.13^{bc}±0.74	7.81^{bc}±0.70	8.19^{b}±0.59	39.70	G
WP (30%W+70% P)	7.25^{b}±o.76	7.44^{b}±0.42	7.38^{c}±0.58	7.44^{c}±0.50	7.0^{c}±0.53	36.51	S
WQ (30%W+70% Q)	8.43^{ab}±0.56	7.75^{ab} ±0.76	8.75^{ab} ±0.38	7.94^{bc}±0.42	8.56^{b}±0.32	41.43	G
WM (30%W+70% M)	8.88^{a}±0.95	8.75^{a}±0.65	9.13^{a}±0.35	9.13^{a}±0.35	9.38^{a}±0.44	45.27	V
LSD	1.10	0.88	0.78	0.76	0.67		

Values are mean ± SD (n=10).
Means ± standard deviations with different superscript letters in the same row are significantly different at (P≤ 0.01).
Values in the same column with different superscript letters are significantly different at p≤0.05. 45-50 Very Good (V). 44.50-40 Good (G). 39.5-35 Satisfactory (S).
W= Wheat flour extraction 72% (control). B = Hulls barley flour. Q= quinoa flour.
P= Proso millet flour. M= Maize flour

Sensory evaluation of crackers produced from double blends of cereals:

Sensory evaluation of crackers made from 30%wheat flour (72% ex.) and double supplemented with different levels of barley, maize, quinoa and proso millet are presented in Table (7). The date showed that blend WMB was higher than other samples on all characteristics values except WPM moreover, blends WBP and WMP reported non-significant differences in all characteristics as compared with control sample except color value in blend WPM and the odor in blend WPB. No significant differences were found between blends WMB, WPB and WPM each other at taste, flavor and crispness values. Furthermore, blend WPQ were the significant lowest values at taste, color , flavor, crispness and over all acceptability as compared with control sample and other blends then blends WMQ and MQB also were recorded the significant lowest values. So, it can be included that blends WMB, WPB and WPM had highest acceptance while blend WPQ had lowest acceptance at overall acceptability as compared with control sample (W).

Table 7. Sensory evaluation of crackers made from wheat flour (72% ex.) supplemented with double of cereals:

Characteristics Blends	Taste (10)	Color (10)	Flavour (10)	Crispness (10)	overall acceptability (10)	Overall Score (50)	Acceptance
Control (100% W)	8.38^{ab}±0.69	8.81^{a}±0.59	8.50^{ab}±0.71	8.56^{ab}±0.62	8.69^{b}±0.53	42.94	G
WMB 30%W+35%M+35%B	8.06^{ab}±1.0	8.56^{a}±0.73	8.06^{a}±0.86	8.44^{a}±0.77	8.25^{a}±0.65	41.37	G
WQB 30%W+35%Q+35%B	7.75^{ab}±0.54	7.50^{b}±0.59	7.25^{ab}±0.46	7.56^{abc}±0.68	7.63^{ab}±0.44	37.69	S
WMQ 30%W+35%M+35%Q	7.25^{bc}±0.27	7.13^{bc}±0.58	7.37^{ab}±0.69	7.31^{bc}±0.37	7.56^{ab}±0.49	36.62	S
WPM 30%W+35%P+35%M	8.06^{ab}±0.73	7.44^{b}±0.49	7.63^{ab}±0.58	7.81^{ab}±0.65	7.69^{ab}±0.79	38.63	S
WPB 30%W+35%P+35%B	8.31^{a}±0.37	7.56^{b}±0.49	7.56^{ab}±0.78	8.06^{ab}±0.49	8.25^{a}±0.93	39.84	G
WPQ 30%W+35%P+35%Q	6.63^{c}±0.69	6.44^{c}±0.56	6.68^{b}±0.75	7.06^{c}±0.68	7.0^{b}±0.96	33.81	
LSD	0.88	0.79	0.95	0.84	0.99		

Values are mean ± SD (n=10).
Means ± standard deviations with different superscript letters in the same row are significantly different at (P≤ 0.01).
Values are mean ± SD (n=10).
Values in the same column with different superscript letters are significantly different at p≤0.05.
45-50 Very Good (V). 44.50-40 Good (G). 39.5-35Satisfactory (S).
W, B , Q, P and M as recorded in table(6).

Sensory evaluation of produce crackers supplemented with formulated of mixes cereals:

Data presented in Table (8) showed that crackers samples in sensory evaluation for taste, color, flavour, crispness and overall acceptability reported that T5 higher than control sample. Also control sample had highest evaluation for taste, flavour and crispness as compared with other blends. T4 had less value than other treatments but did not show significant change in overall acceptability compared with T1and T2 that had less values after T4. On the other hand, T2 did not report significant change between each other in taste and color characteristics. Although values were near to the same value, the values referred to significant differences as compared with other simples in taste, color, flavor, crispness and overall acceptability except T5 and control. Finally, it could be noted that T5 had the highest overall acceptability and color as compared with control simple.

Chemical composition and nutritive values of crackers made from different flour blends:

Chemical analysis of crackers made from different flour blend used in this study (as shown in Table 9) were chemically analyzed for their contents of moisture, protein, ether extract, ash, crude fiber and available carbohydrates. The obtained results are presented in Table (9). In respect of moisture content, it could be noted that control had a low level of moisture content (12.50%). Blend II had the highest moisture content (13.59) and no significant differences between crackers made from different blends and control. Table (9) show that, protein is the main constituent of the prepared crackers meal which recorded 12.69 and 11.1% in Type I and III, respectively. Removal of most W.F increased the ether extract from 1.75% of control to 4.76 and 3.17% in crackers made from blends. Type I and IV, respectively. Ash content increased in blend I (3.01%), and other results were close together. Also crude fiber was highest in blend II (6.32%) and decreased to (1.56%) in control crackers. On the other hand, the calculated energy showed that cracker made from 30% W.F+70% Q.F (Blend I) was the highest than all Blends. Available carbohydrate is the main constituted the prepared crackers and showed a significant differences between control crackers and the crackers made from different blends, but no significant differences in different blends.

Table 8. Sensory evaluation of produce crackers supplemented with formulated of mixes cereals:

Characteristics Treatment	Taste (10)	Color (10)	Flavor (10)	Crispness (10)	overall acceptability (10)	Overall Score (50)	Acceptance
Control (100%W)	8.95^a± 0.60	8.55^a± 0.50	8.85^a± 0.47	8.90^a± 0.46	8.65^a± 0.41	43.90	G
T1 (30%W+20%B+25%M+25%P)	7.38^b± 0.88	7.50^b±0.65	7.63^b±0.74	7.37^b±0.88	7.56^b±0.56	37.44	S
T2 (30%W+20%M+25%B+25%P)	7.56^b±0.94	7.75^b±0.46	7.44^b±0.56	7.50^b±0.59	7.69^b±0.53	37.94	S
T3 (30% W + 20% Q +25% B + 25% P)	8.30^a ±0.42	7.85^a ±0.58	7.85^a ±0.58	7.85^a ±0.58	8.30^a±0.62	40.15	G
T4 (30% W + 20% P +25% B + 25% Q)	7.44^b±1.08	7.44^b±0.56	7.50^b±0.54	7.31^b±0.46	7.56^b±0.62	37.25	S
T5(20%W+20%B+20%M+20%P+20%Q)	8.94^a±0.32	8.75^a±0.75	8.63^a±0.79	8.63^a±0.64	9.13^a±0.52	44.08	G
LSD	1.28	0.88	0.95	0.93	0.91		

Values are mean ± SD (n=10).
Means ± standard deviations with different superscript letters in the same row are significantly different at (P≤ 0.01).
Values in the same column with different superscript letters are significantly different at p≤0.05.
45-50 Very Good (V). 44.50-40 Good (G). 39.5-35Satisfactory(S).
W, B , Q, P and M as recorded in table(6).

Table 9. Chemical composition and nutritive values of crackers made from different flour blends (on dry weight basis).

Constituent%	Types of crackers				
	Control	I	II	III	IV
Moisture	12.50^a±0.43	13.25^a±0.43	13.94^a±0.42	13.59^a±0.47	12.95^a±0.43
Crude Protein	9.80^b±0.53	12.69^a±0.45	10.45^b±0.56	11.10^b±0.42	10.60^b±0.45
Ether Extract	1.75^c±0.34	4.76^a±0.34	1.98^c±0.35	2.75^{bc}±0.36	3.17^b±0.43
Crude Fiber	1.56^c±0.36	3.14^b±0.26	6.32^a±0.49	5.20^a±0.40	5.40^a±0.28
Ash	1.16^b±0.29	3.01^a±0.34	1.98^b±0.45	2.20^a±0.18	2.30^a±0.36
*Available Carbohydrate	85.73^a±1.45	76.40^b±1.11	79.27^b±0.8	78.75^b±0.9	78.53^b±1.5
K cal /100g	397.87	399.20	376.70	384.15	385.05

***Available carbohydrates were calculated by difference**
Where:
(Control=100%W.F), I (30% W.F + 70% Q.F), II (30% W.F+ 35% B.F+35%P.F), III (30%W.F+20% Q.F+25% B.F+25%P.F), IV (20% W.F+ 20% Q.F+20% B.F+20% P.F+20% M.F).

Minerals content of crackers:

Some minerals content, iron (Fe), Zinc (Zn), calcium (Ca) sodium (Na), potassium (K), magnesium (Mg) and phosphorus (P) of crackers made from different flour blends were determined. Data given in Table (10) show the mineral elements composition of crackers prepared from control and different blends.

Table 10. Minerals content (mg/100g on dry weight basis) of crackers.

Minerals (mg/100g)	control	I	II	III	IV
Calcium (Ca)	32.8	69.70	24.29	40.16	34.33
Phosphorus (P)	442.3	396.41	400.54	400	338.86
Iron (Fe)	2.6	7.63	3.95	6.03	4.60
Potassium (K)	483	667.77	440.74	518.38	468.8
Sodium (Na)	17.30	14.65	18.92	19.17	16.84
Magnesium(Mg)	149.5	219.21	136.32	159	157.11
Zinc (Zn)	2.90	2.94	3.30	3.34	3.34

Where:
(Control=100%W.F), I (30% W.F + 70% Q.F), II (30% W.F+ 35% B.F+35%P.F), III (30%W.F+20% Q.F+25% B.F+25%P.F), IV (20% W.F+ 20% Q.F+20% B.F+20%P.F+20% M.F).

It could be concluded that, crackers (Blend I) contains high content of Ca, Fe, K, and Mg compared with other blends. The values of these elements in type I were 69.70, 7.63, 667.77 and 219.21 mg/100g samples, respectively. While crackers made from blend III (30%W.F+ 20%Q.F+ 25%B.F+25%P.F) contained high amounts of Na and Zn than other crackers types which contained 19.17 and 3.34 mg/100g samples, respectively follow by blend II (30% W.F+ 35% B.F+35% P) also high amounts of Na and Zn they were 18.92 and 3.3, respectively. While control contained high amounts of P (442.3 mg/100g samples). These differences of minerals content in different crackers referred to type of flour in each blend and the percentage.

Vitamins Contents of crackers:

The vitamins were determined in crackers made from different blends I, II, III, IV and reported as mg/100g of dry weight samples. Results in Table (11) showed that crackers are an important source of vitamins that helps to release energy from foods, promotes normal appetite, and is important in maintaining proper nervous system function (DRI,1998) The contents of vitamins in crackers made from different flours were recorded in Table (11). Blend II recorded the highest values with thiamine and niacin were 0.45mg, and 5.43 mg/100g, respectively. Also results showed that values of Type III the highest value of β-Carotene and tocopherols which contained 0.63IUand 2.81IU respectively. Vitamin C was recorded lowest value in all types. Most commonly, thiamin is found in whole grains and fortified grain products such as cereal, and enriched products like bread, pasta, rice, and tortillas Biochemical, Physiological, Molecular Aspects of Human Nutrition (2006).

Table 11. Vitamins of plain crackers (on dry weight basis).

Vitamins (mg/100g)	control	I	II	III	IV
β-Carotene (IU)	0.01	0.43	0.58	0.63	0.26
V.B1(Thiamine)(mg)	0.33	0.15	0.45	0.41	0.39
V.B2 (Riboflavin)(mg)	0.18	0.10	0.20	0.15	0.21
V.B3 (Niacin)(mg)	3.85	0.95	5.43	3.75	4.02
V. C(Ascorbic acid)(mg)	0.01	0.06	0.04	0.05	0.09
V. E (Tocopherols) (IU)	1.12	1.94	1.33	2.81	2.4

Where:
(Control=100% W.F), I (30% W.F + 70% Q.F), II (30% W.F+ 35% B.F+35%P.F), III (30%W.F+20% Q.F+25% B.F+25%P.F), IV (20% W.F+ 20% Q.F+20% B.F+20%P.F+20% M.F).

Percentage of the recommended dietary allowances (%RDA) for some nutrient provided from 100g of crackers for Children:

Multiple micronutrient (MMN) deficiencies often occur simultaneously as a result of a poor-quality diet. In developing countries, low dietary intakes of animal source foods (Schurch, 1995) which are important source of iron, zinc, vitamin E, B_2 and protein, can lead to MMN deficiencies (Ramakrishnan and Huffman,2008).

Recent dietary guidelines emphasize a need for whole grains and a variety of vegetables and fruits in adolescents diets to ensure an adequate intake of micronutrients (Nutrition and Your Health, 2005). Because eating behaviors developed during adolescence can have both immediate health implications and influences on future chronic disease risk (Stockman *et al.*,2005).

The percentage of the recommended dietary allowances (%RDA) that provided from 100g of produced crackers for children (4-8 years) are showed in Table (12),the percentage values of protein, Fe, Zn, V.E and V.B2 are more than of that reported by National Academy of Science (2004). Meanwhile, levels of carbohydrates, energy, TDF, Ca and K are lowest than that of RDA for this category of children. Moreover, the highest value were recorded with Mg (115.00, 168.62, 104.87, 122.30 and 120.85%) while, the lowest ones were recorded with Ca (3.28, 6.97, 2.43, 4.02 and 3.43%), TDF (6.24, 12.56, 25.28, 20.80 and 21. 60%) then K (12.71, 17.57, 11.59, 13.64 and 12.34%) of all the types of crackers.

Table 12. Percentage of the recommended dietary allowances (%RDA) for some nutrient provided from 100g of crackers for Children.

Age	Components	RDA*	%RDA				
			Types of crackers				
			Control	I	II	III	IV
Children (4-8) years	Carbohydrate	(130gm)	65.95	58.77	60.98	61.58	60.41
	Protein	(19gm)	51.58	66.79	55.00	58.42	55.79
	Energy	(1742K.cal)	22.84	22.92	21.62	22.05	22.10
	TDF	(25g)	6.24	12.56	25.28	20.80	21.60
	Fe	(10mg)	26.00	76.30	39.5	60.30	46.00
	Zn	(5mg)	58.00	58.80	66.00	66.80	46.80
	Ca	(1000mg)	3.28	6.97	2.43	4.02	3.43
	Mg	(130mg)	115.00	168.62	104.87	122.30	120.85
	K	(3800mg)	12.71	17.57	11.59	13.64	12.34
	(Tocopherols)V.E	(7mg)	16.00	27.71	19.00	40.14	34.29
	Riboflavin V.B2	(0.6mg)	30.00	16.67	33.33	25.00	35.00

***RDA= Recommended dietary allowances from the Dietary Reference Intakes according to Food and Nutrition Board as reported by National Academy of Science (2004). % RDA=Value of nutrient in sample of crackers× 100 / RDA for the same nutrient.TDF =Total dietary fiber**
Where: (Control=100%W.F), I (30% W.F + 70% Q.F), II (30% W.F+ 35% B.F+35%P.F), III (30%W.F+20% Q.F+25% B.F+25%P.F), IV (20% W.F+ 20% Q.F+20% B.F+20%P.F+20% M.F).

CONCLUSION

From this study it could be concluded that incorporated of wheat flour with different sources of whole meal cereals (ex. Maize, naked barley, quinoa and proso millet flours) caused rising in nutrition value; minerals and vitamin content and of produced crackers, and it is recommended to incorporation the mentioned cereals in bakery products.

REFERENCES

A.O.A.C. (2012). Association of Official Analytical Chemists. Official Methods of Analysis, 19th (ed). Mary Land, USA.

Al Shehry, G. A. (2016). Use of corn and quinoa flour to produce bakery products for celiac disease. Advances in Environmental Biology, 10(12):237-244.

Anandito, R. B. K.; Oktaliana, M. and Nurhartadi, E. (2019). Formulation of Emergency Food in Flakes Form Made from Proso Millet Flour (*Panicum milliaceum*) and Snakehead Fish (*Channa striata*)-Tempeh Flour Koya. In IOP Conference Series: Earth and Environmental Science (Vol. 246, No. 1, p. 012028). IOP Publishing.

Awika, J.M.; Dykes, L.; Gu, L.; Rooney, L.W. and Prior, R.L. (2003). Processing of sorghum alters procyanidin oligomer and polymer distribution and content. Journal of Agricultural Food Chemistry, 51:5516-5521.

Bhushan, R. (2004). Amino acids and their derivatives. In: Handbook of TLC, Sherma, J. and fried, B. (eds.) Mercel Dekker Puplishers, New York and Hongkong, 353-387.

Biesiekierski, J.R.; Muir, J.G. and Gibson, P.R. (2013). Is gluten a cause of gastrointestinal symptoms in people without celiac disease? Curr. Allergy Asthma Rep., 13(6):631–638.

Biochemical, Physiological, Molecular Aspects of Human Nutrition. (2006). Saunders, Elsevier Inc., 9:315.

Bose, D. and Shams-Ud-Din, M. (2010). The effect of chickpea (*Cicerarietinim*) husk on the properties of cracker biscuits. Journal of the Bangladesh Agricultural University, 8(1):6.

Bora, P., Das, P., Mohan, P., and Barthakur, A. (2018). Evaluation of hypolipidemic property of proso millet (*Panicum miliaceum L.*) in high fat diet induced hyperlipidemia in rats. J Entomol Zool Stud, 6(3): 691-5.

Brand-Williams, W.; Cuvelier, M.E. and Berset, C. (1995). Use of free radical method to evaluate antioxidant activity. Food Science and Technology, 28(1): 25-30.

Chandra, D.; Chandra, S. and Sharma, A. K. (2016). Review of finger millet (*Eleusine coracana (L.) Gaertn*): a power house of health benefiting nutrients. Food Science and Human Wellness, 5(3):149-155.

Chethan, S. and Malleshi, N. (2007). Finger millet polyphenols: Optimization of extraction and the effect of pH on their stability. Food Chem., 105(2):862-870.

Dangeti, S.R.; Karthikeyan, S.; Kumar, G.R. and Desai, S. (2013). Proximate and phytochemical analysis of seed coat from P. sumantranse (*Little Millet*), Biochem. Anal. Biochem., 2,1

Davedson, S.; Passmore, R.; Bock, F.J. and Truswell, S.A. (1973). Human Nutrition and Diabetics. Churchill, Living- Stone, New York, USA.

Devi, P. B.; Vijayabharathi, R.; Sathyabama, S.; Malleshi, N. G. and Priyadarisini, V.B. (2014). Health benefits of finger millet (*Eleusinecoracana L.*) polyphenols and dietary fiber: a review. Journal of Food Science and Technology, 51(6):1021-1040.

Dewettinck, K.; Van Bakstaele, F.; Kuhne, B.; Walle, V.; Courtens, T.; and Gellynck, X. (2008). Nutritional value of bread: Influence of processing food interaction and consumer perception. Rev. J. Cereal Sci., 48: 243-257.

DRI. (1998). Dietary Reference Intakes. Water souluble vitamins for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline. Washington, D.C: National Academy Press, 27 -37.

Eidi, A.; Eidi, M. and Sokhteh, M. (2007). Effect of fenugreek (*Trigonella foenum-graecum L*) seeds on serum parameters in normal and streptozotocin-induced diabetic rats. Nutrition Research, 27(11):728-733.

FAO / WHO/ UNU (1990). Energy and protein requirements report of a joint FAO/WHO /UNU expert consultation, World Health Organization, Technology. Department, Series, 724, WHO, Geneva, Switzerland.

Farag, S.A.; Elshirbeeny, A. and Ashga, E.N. (1996). Physicochemical studies for preparing quick cooking rice by using gamma irradiation. Analysis of Agriculture Science, Moshtohor, 34(2):641-652.

Farooqui, A. S.; Syed, H. M.; Talpade, N. N.; Sontakke, M. D. and Ghatge, P. U. (2018). Influence of germination on chemical and nutritional properties of Barley flour. Journal of Pharmacognosy and Phytochemistry, 7(2):3855-3858.

Fraser, J .R. and Holmes, D .C. (1959). Proximate analysis of wheat flour carbohydrates. Analysis of whole meal flour and some of its fractions. Journal of the Science of Food and Agriculture, 10 (9):506-512.

Fung, T.T., Hu, F.B.;Pereria, M.A.; Liu, S.; Stampfer, M.J.; Colditz, G.A. and Willett, W. C. (2002). Whole-grain intake and the risk of type 2 diabetes: a prospective study in men. Am J Clin Nutr; 76:535–40.

Gabel-Jensen, C.; Lunøe, K.; Madsen, K. G.; Bendix, J.; Cornett, C.; Stürup, S. and Gammelgaard, B. (2008). Separation and identification of the selenium-sulfur amino acid S-(methylseleno) cysteine in intestinal epithelial cell homogenates by LC-ICP-MS and LC-ESI-MS after incubation with methylseleninic acid. Journal of Analytical Atomic Spectrometry, 23(5):727-732.

Gebrezgi, D. (2019). Proximate composition of complementary food prepared from maize (*Zea mays*), soybean (*Glycine max*) and Moringa leaves in Tigray, Ethiopia. Cogent Food and Agriculture, 5(1):1627779.

Holtekjølen, A.K.; Kinitz, C. and Knutsen, S. H. (2006). Flavanol and bound phenolic acid contents in different barley varieties, J Agric Food Chem.,4(6): 2253-2260.

Kirk, R.S. and Sawer, R. (1991). Pearson's Composition and Analysis of Food. 9th (ed) Longman Scientific and Technical, London, England, 469-529.

Lanyon, L.E. and Heald, W.R. (1982). Magnesium, Calcium, Strontium and barium. Analysis , Part 2. Chemical and Microbiological Properties. (2nd ed.). Sco. Of Agron. Inc., Madison, Wis, USA,*9*: 247-262.

Lawrence, R.D. (1965). The diabetic life. Journal and A. Churchill, LTD. London.

Martirosyan, D. and Singh, J. (2015). A new definition of functional food by Functional Food Center (FFC): what makes a new definition unique?. Functional Foods in Health and Disease, 5(6):209-223.

Mazza, G.; Fukumoto, L.; Delaquis, P.; Girard, B. and Ewert, B. (1999). Anthocyanins, phenolics, and color of Cabernet franc, Merlot, and Pinot noir wines from British Columbia. Journal of Agricultural and Food Chemistry, 47 (10): 4009-4017.

Mc-Dowell, L.R (2003). Minerals in Animal and Human Nutrition (2nd edn). Elsevier, Amsterdam.

Miller, M.L. (1967). Determination of the tryptophan content of feeding stuffs with particular reference to cereals. Science Food Agriculture, 18 (9) :381.

Mlyneková, Z.; Chrenková, M. and Formelová, Z. (2014). Cereals and legumes in nutrition of people with celiac. International Journal, 2(3):105-109.

Mohamed, A. A.; Babiker, E. M.; Khalid, A. G.; Mohammed, N. A. and Khadir, E. K. (2016). Nutritional evaluation and sensory characteristics of biscuits flour supplemented with difference levels of whey protein concentrates, Journal of Food Processing and Technology, 7(1): 545 ref.21.

Murphy, J. and Riley, J.P. (1962). A modified single solution method for determination of phosphate in natural waters. Analysis Chemistry. Acta., 27: 31-36.

National Academy of Science (2004). Dietary reference Intakes (DRIs) Estimated average Requirements Food and Nutrition Board, Institute of Medicine, National Academies as reports by accessed via http://www.nap.edu.

Nawaz, H.; Muzaffar, S.; Aslam, M. and Ahmad, S. (2018). Phytochemical Composition: Antioxidant Potential and Biological Activities of Corn. Corn: Production and Human Health in Changing Climate, 49-68.

Nowak, V.; Du, J. and Charrondière, U.R. (2015). Assessment of the nutritional composition of quinoa (*Chenopodium quinoa Wild*). Food Chemistry; 193:47-54.

Nutrition and Your Health (2005). Dietary Guidelines for Americans.6th (ed). Washington, DC: US Department of agriculture and Health and Human Services.

Omobuwajo, T. O. (2003). Compositional characteristics and sensory quality of biscuits, prawn crackers and fried chips produced from bead fruit. Innovative Food Science and Emerging Technologies, 4(2): 219-225.

Pearson, D. (1976). The Chemical Analysis of Foods, 7th (ed). Churchill, London, U.K.

Poutanen, K.; Sozer, N.; Della and Valle, G. (2014). How can technology help to deliver more of grain in cereal foods for a healthy diet? J. Cereal Sci., 59(3):327–36.

Puupponen-Pimiä, R.; Nohynek, L.; Alakomi, H. L. and Oksman-Caldentey, K. M. (2005). Bioactive berry compounds novel tools against human pathogens. Applied Microbiology and Biotechnology, 67(1):8-18.

Radovanović, B. and Radovanović, A. (2010). Free radical scavenging activity and anthocyanin profile of Cabernet Sauvignon wines from the Balkan region. Molecules, 15(6): 4213-4226.

Ramarkishnan, U. and Huffman, S.L. (2008). Multiple micronutrient malnutrition: what can be done? In: Semba RD, Bloem MW, (eds). Nutrition and Health in Developing Countries, 2nd (ed). Totowa, N.J.: Humana press, Inc., 531-567.

Sadasivam, S. and Manickam, A. (1992). Determination of fructose, Inulin and Amino Acids. Agriculture Science, Wiley Eastern Limited, New Delhi, India, 15-60.

SAS, (1985). SAS User's Guide statistics, Version (2) 5th Edition. Cony, Nc: SAS. Institute.

Schlenker, E.D. and Williams, S.R. (2003). Essentials of Nutrition and Diet Therapy. Elsevier, Amsterdam.

Schurch, B. (1995). Malnutrition and behavioural development: the nutrition variable. Journal of Nutrtion, 125(8): 2255- 2262.

Srujana, M. N. S.; Kumari, B. A.; Suneetha, W.J. and Prathyusha, P. (2019). Processing technologies and health benefits of quinoa, 8(5): 155-160.

Stockman, N. K.; Schenkel, T.C.; Brown, J. N. and Duncan, A.M. (2005). Comparison of energy and nutrient intakes among meals and snacks of adolescent males. Prev. Med., 41(1): 203 - 210.

Stone, H. (2012). Sensory evaluation practices. Academic press, 4th edition.

Sullivan, P.; O'Flaherty, J.; Brunton, N.; Gee, V. L.; Arendt, E. and Gallagher, E. (2010). Chemical composition and microstructure of milled barley fractions. European Food Research and Technology, 230(4): 579-595.

Taylor, J.R.N. and Emmambux , M.N. (2008). Gluten-free foods and beverages from millets. In: Gluten-free cereal products and beverages. Arendt, E.K. and Bello, F.D. (dds.). Academic Press. N.Y., 119-148.

Thathola, A.; Srivastava, S. and Singh, G. (2011). Effect of foxtail (*Setaria italica*) supplementation on serum glucose, serum lipids and glycosylated haemoglobin in type 2 diabetics. Diabetologia Croatica, 40(1):23-28.

Truswell, A.S. (2002). Cereal grains and coronary heart disease. Eur J Clin Nutr, 56:1–14.

Vega-Galvez, A.; Miranda, M.; Vergara, J.; Uribe, E.; Puente, L. and Martinez, E.A. (2010). Nutrition facts and functional potential of quinoa (*Chenopodium quinoa Willd.*). An ancient Andean grain: a review. Journal Sci. Food Agric., 90(15): 2541–2547.

Wood, P. J. (2007). Cereal β-glucans in diet and health. Journal of Cereal Science, 46(3): 230-238.

Yaseen, A. A.; Shouk, A. A. and Ramadan, M. T. (2010). Corn-wheat pan bread quality as affected by hydrocolloids. Journal of American Science, 6(10):684-690.

Zhishen, J.; Mengcheng, T. and Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food chemistry, 64(4): 555-559.

إعداد وتقييم مقرمشات صحية بإستخدام خلطات دقيق أنواع مختلفة من الحبوب

مني حسين حسن[١] ، موسي عبده سالم[٢] و منى محمود دويدار[١]

[١]قسم بحوث الخبز و العجائن – معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية – جيزة – مصر.

[٢]قسم الصناعات الغذائية - كلية الزراعة – جامعة طنطا

تهدف هذه الدراسة إلى إعداد مقرمشات صحية عالية القيمة الحيوية وذلك بعمل عدة خلطات متوازنة باستخدام دقيق القمح استخلاص ٧٢% مع دقيق أنواع مختلفة من الحبوب (مطحون الحبة الكامل) مثل دقيق الذرة ، الشعير، الكينوا والدخن). و بتقييم أنواع الحبوب المستخدمة وجد أن دقيق الكينوا احتوي علي أعلي نسبة في البروتين، الدهن والرماد (١٦,٧٠ ، ٧,١٠ و ٣,٨٠% علي التوالي). بينما احتوى دقيق القمح علي اعلي نسبة من الكربوهيدرات (٨٤,٤٠ %)، واحتوي الدخن علي أعلي نسبة في الألياف الخام (١٤,٨٠%).و سجل دقيق الكينوا أعلي محتوي تركيز من الكالسيوم ، الحديد، البوتاسيوم والماغنسيوم (٨٥,١ و٩,٧و٧٩٧,٣و ٢٤٩,٦ ملجم/١٠٠جم علي التوالي)، واظهر دقيق الشعير أعلي محتوي في الفوسفور ويليه دقيق القمح (٤٨٩و٤٦٧,٧ ملجم/١٠٠جم علي التوالي)، واظهر دقيق الدخن أعلي محتوي من الصوديوم والزنك (٣٥,١ و١٢٣,٣.ملجم/١٠٠جم علي التوالي).وسجل البيتاكاروتين اعلي محتوي في دقيق الذرة (٨٦, ٠ وحدة دوليه بينما سجل الثيامين أعلي محتوي في دقيق كل من القمح والدخن (٥٦, ٠ و ٥٢, ٠٥ ملجم/١٠٠جم علي التوالي) وكان الريبوفلافين اعلي محتوي في دقيق الدخن (٢٩, ٠ملجم/١٠٠جم) وسجل دقيق الشعير اعلي محتوي في النياسين(٦,١١ ملجم/١٠٠جم) وسجل دقيق الكينوا ارتفاع ملحوظ في حمض الاسكوربيك وفيتامين ه (٤٠, و ٥,٤٣ ملجم/١٠٠جم علي التوالي). سجل دقيق الكينوا أعلي محتوي من الأحماض الأمينية الضرورية الكلية ويليها دقيق الذرة وتقاربت النسب بين باقي أنواع الدقيق الأخرى. وأظهرت النتائج أن دقيق الشعير الأعلى في مضادات الأكسدة (١١,٣٧%) بينما كانت الفينولات الكلية الأعلى في دقيق الكينوا (٤,٤٢ ملجم/١٠٠جم) ،وكان دقيق الذرة أعلي في محتوي الفلافونيدات الكلية (٢,٣٥ ملجم/١٠٠جم). وجد ان المقرمشات المصنعة من الخلطة الأولي(٣٠% دقيق قمح+٧٠% دقيق كينوا) هي الأعلى في محتواها من البروتين الخام ،الدهن ،الرماد والعناصر المعدنية (الكالسيوم، الحديد ، ،البوتاسيوم و الماغنسيوم) ،بينما إحتوت مقرمشات الخلطة الثانية (٣٠% دقيق قمح+٣٥% دقيق شعير+٣٥% دقيق دخن) على المحتوي الأعلي من فيتامين ب١، ب٣.بينما كان محتوي البيتاكاروتين والتوكوفيرول الأعلي في مقرمشات الخلطة الثالثة (٣٠% دقيق قمح+٢٠% دقيق كينوا+٢٥% دقيق شعير+٢٥% دقيق دخن) بينما كانت مقرمشات الخلطة الرابعة (٢٠% دقيق قمح+٢٠% دقيق كينوا+٢٠% دقيق شعير+٢٠% دقيق دخن+٢٠% دقيق ذرة) الأعلي في محتواها من الرايبوفلافين وحمض الاسكوربيك مقارنة بالكنترول. وجد أن كل أنواع المقرمشات الناتجة من خلطات الحبوب المقترحة هي الأعلى بالنسبة لتغطية الاحتياجات اليومية الموصى بها لجميع المغذيات المدروسة السابقة للأطفال من (٤ الي ٨ سنوات) مقارنة بالعينة الكنترول (غير المدعم بأنواع الدقيق الاخري). وتوصي نتائج هذه الدراسة بإستخدام هذه المصادر من الحبوب لعمل منتجات صحية عالية القيمة الحيوية.

الكلمات الدالة:المقرمشات، دقيق القمح ،الذرة ، الشعير، الكينوا والدخن،القيمة الغذائية .