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Nutritional evaluation and functional properties of quinoa (*chenopodium quinoa* willd) flour

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Abstract

Present study was carried out to evaluate the physical, chemical, nutritional and functional properties of quinoa seeds flour. Results showed that, the 1000-seed weight and the bulk density values of quinoa seeds were 2.71g and 0.80g/m^3, respectively. The chemical composition obtained data indicated that quinoa seeds flour contained 13.55, 7.30, 2.69, 3.45 and 63.56% for crude protein, crude fibers, ash, fat and total carbohydrates, respectively. Amino acids compositions of quinoa flour had a well-balanced amino acids composition especially lysine (4.67g/100gprotein).Also, quinoa seed flour oil was rich in unsaturated fatty acids, with unsaturated to saturated ratio observed from quinoa was86.9:13.1. On the other hand, biscuits prepared with replacing either of 50% of quinoa seeds flour or 75% of rice had overall acceptability which was not significant ($P\leq 0.05$) different comparing with to that of control biscuits. Also, physical properties, such as volume, weight, diameter and thickness of biscuits from different blends of rice and quinoa seeds flours showed that as the level of quinoa flour increased, the volume of biscuits decreased gradually. On the other side, chemical analysis and caloric values of biscuits from different blends of rice flour and quinoa flour showed that protein, fat, ash and crud fiber contents of flour-replaced biscuits were higher than that of the control biscuits.

Key words: Quinoa flour-*Chenopodium* quinoa –Biscuits.

Introduction

Quinoa (*Chenopodium quinoa* Willd.) is a pseudo-cereal which can be eaten as a rice replacement, as a hot breakfast cereal, or boiled in water to make an infant cereal. Also, whole seeds are used in soups, salads, casseroles, chilli and stew, as well as roasted and ground in several kinds of desserts and can even be popped like popcorn. Seeds can be ground and used as flour, or sprouted. The leaves of quinoa are compared to spinach as regards flavor. Quinoa leaves are cooked as a green vegetable or used raw in salad. Leaves, like the seed, can also be cooked, made into spinach-like dish, or may be served raw in a salad **(Valencia-Chamorro, 2003)**.

The quinoa is an excellent example of ‘functional food’ that aims to lowering the risk of various diseases. Functional properties are given also by minerals, vitamins, fatty acids and antioxidants that can make a strong contribution to human nutrition, particularly to protect cell membranes, with proven good results in brain neuronal functions. Also, contains phytohormones, which offer an advantage over other plant foods for human nutrition **(Vega-Galvez *et al.*, 2010).**

Nsimba *et al.* (2008) determined the total phenolic content (TPC) and DPPH free radical scavenging activity (IC50). The TPC content ranged from 14.22 to 65.53mg/100g DW for the six ecotypes. Ecotype presented the best results (lowest IC50 values of 461.89 µg/mL), while ecotype presented the worst results (3773.37 µg/mL).

Jancurova *et al.* (2009) determined the chemical composition of quinoa seeds flour (% dry basis) including protein, fat, fiber, ash and carbohydrates which were found to be 16.5, 6.3, 3.8, 3.8 and 69.0%, respectively.

Alvarez-Jubete *et al.* (2010) mentioned that quinoa had a high content of protein (13.1%) all essential amino acids were found to be present in quinoa and the amino acid pattern was close to the requirements. Specifically, quinoa proteins were high in lysine (4.8 g/100 g protein) and threonine (3.7 g/100 g protein), which were in general the limiting amino acids in conventional cereals but lower contents in leucine (6.0 g/100 g protein) and valine (3.7 g/100 g protein).

Miranda *et al.* (2011) analyzed six different quinoa cultivars and recorded that the vitamin B contents were ranged from 0.349 to 0.648 mg/100g for B1; 0.056 to 0.081 mg/100g for B2 and 0.562 to1.569 mg/100g for B3. Another interesting result was the amount of vitamin E (α-Tocopherol) found in the six different quinoa cultivars which ranged from 2.445 to 4.644 mg/100g.

Miranda *et al.* (2012) compared some commercial quinoa varieties grown in Chile. The protein content ranged from 11.41 to 16.10%, the available carbohydrate ranged from 56.73 to 68.36%. Ash ranged between 3.15 and 3.61%, fat ranged from 5.88 to 6.59% and the crude fiber ranged from 1.33 to 2.81%.

Nascimento *et al.* (2014) showed that quinoa flour consisted of 2.01% ash, 12.10% protein, 6.31% fat, 10.4% fiber and 57.2% starch.

Abderrahim *et al.* (2015)reported that quinoa area was 2.31–4.71 mm^2 and perimeter 5.69–8.17 mm of coloured quinoa seeds which were closer to previous report for quinoa varieties from Europe and Peruvian Altiplano region (Area = 2.56–5.1 mm^2 and perimeter = 6.04–8.65 mm).

The objective of the present study is a trial to determine the physico-chemical properties, amino acids,fatty acids, minerals, vitamins, antioxidant activity.

Also, this study was conducted to prepare biscuits from whole quinoa flour to examine nutritional composition and physicochemical properties in gluten-free biscuits formulation and its relation to final product quality.

Materials and Methods

Quinoa (*Chenopodium quinoa* Willd) was brought from Crop Intensification Research Section Field Crops Research Institute, Agriculture Research Center (Giza, Egypt), season 2012(Giza, Egypt)., rice flour, corn flour, butter, eggs, sugar powder, baking soda (baking powder), vanilla, corn oil, salt and herbs were purchased from local market. Chemicals used were obtained from El–Gomhoria Company, Cairo, Egypt.

Physical properties of quinoa seeds: Quinoa seeds were manually cleaned to remove foreign matter, broken and immature seeds. Then, subject to determined physical properties as follows:

Spatial dimensions and size: Size of the seeds three sub-samples, from each of the subsamples, 200 seeds were picked out, 100 seeds were randomly selected and labelled for easy identification **(Joshi *et al*., 1993).** For each individual seed, length (l) and width (w) were measured using a micrometer (least count 0.01 mm) at ten replications.

Gravimetric properties: To obtain the mass, each seed was weighed on a precision electronic balance (reading to 0.001 g). The weight of 1000 seeds W_{1000} was determined by weighing 100 seeds in triplicate and then extrapolating this weight to 1000 seeds.

The bulk density *pb*: The bulk density (*pb*) considered as the ratio of the mass sample of the seed to its total volume was determined using a standard equipment of 250ml of total volume with a piston for air displacement **(Vilche *et al.*2003).**

Test weight is expressed in kilograms per hectolitre (i.e. the weight of a hundred litres).This method was applied according to **Gloria, (2013).** Hectolitre weight (HLW) was determined using a Dickey-John GAC2100 where 500g of quinoa was poured into the top hopper. The grain was dumped into the cell where moisture and weight was measured. HLW was reported as kg/Hl.

Preparation of quinoa seeds flour (QF): Fresh quinoa was subjected to visual inspection to discard contaminant particles or impurities. Quinoa seeds flour was prepared according to **Miranda *et al.* (2010).**

Chemical analysis: The proximate composition of quinoa seeds flour was determined according to the methods described by **AOAC(2010).** The moisture, crude protein, crude fat, ash and fiber contents were determined. The carbohydrate content was calculated by subtracting the sum of percentage of moisture, protein, fat, ash and fiber from 100%.

Caloric value was calculated according to **Eneche (1999)** by multiplying the proportions of protein, fat and digestible carbohydrate by their respective physiological fuel values of 4, 9 and 4 kcal/g, respectively, and taking the sum of the products.

Amino acids determination of quinoa seeds flour was performed according to the method described by **AOAC (2010)** using the amino acid analyzer Biochrom30.

Nutritional quality parameters of quinoa seeds flour were calculated using their amino acid composition as described by **Zhu *et al.* (2006)** as follows:

The amino acid score (AAS) of samples was calculated as follows:

$$\mathbf{AAS} = \frac{\mathbf{Aminoacid\ (mg)/testproteinsample\ (g)}}{\mathbf{Aminoacid\ (mg)/FAO/WHO/UNUreferenceprotein\ (g)}}\ \mathbf{x\ 100}$$

The FAO/WHO reference pattern of essential amino acid requirements (g/100 g of protein) **(FAO/WHO, 1973**) was used as the standard. The AAS indicated the most limiting amino acid of the protein compared to a reference protein.

Protein efficiency ratio (PER) values of quinoa seeds flour was estimated by two regression equations developed by **Alsmeyer *et al.* (1974)** as follows:

1) PER_A = -0.684 + 0.456 (Leu) -0.047 (Pro)

2) PER_B = -0.468 + 0.454 (Leu) -0.105 (Tyr)

All the amino acids used in the equations were (g/100 g protein)

Biological value (BV) was calculated using the regression equation of **Eggum *et al.* (1979)** as follows:

Biological value (%) = 39.55 + 8.89 × lysine (g/100 g protein)

Protein digestibility (*in vitro*) was determined according to method described by **Aksson and Stammann (1983)** as the equation:

$$\mathbf{Protein\ digestibility\ (\%)} = \frac{\mathbf{Protein\ content\ in\ the\ supernatant - Protein\ content\ in\ the\ blank}}{\mathbf{Protein\ content\ in\ the\ sample}} x\mathbf{100}$$

The fatty acids of the quinoa oils were converted to methylesters by using sodium methoxide according to the method of **Hougen and Bodo (1973).**

Mineral contents of quinoa seeds flour (magnesium, sodium، zinc, manganese, iron, calcium, potassium and copper) were determined by using the flame photometer (Galienkamp, FGA 330, England) and

Perkin Elmer Atomic Absorption Spectrophotometer. (model 80, England) as described in **AOAC (2010).**

Acid value and peroxide value were determined according to the method outlined in the **AOAC (2010)**

Antioxidant activity (DPPH radical scavenging activity): Preparation of crude extracts solutions from quinoa according to **Hirose *et al.* (2010),** and determined of DPPH with some modifications by **Fischera *et al.* (2013).**

Functional properties

The water absorption index (WAI), water solubility Index (WSI) were measured according to **Anderson *et al*. (1969).**

Swelling power (SP)

Swelling power is the ratio of weight of the wet sediment to the initial weight of dry starch. The method of **Collado *et al*. (2001)** was used to determine the swelling power.

Bulk density (BD) was determined by the method of **Wang and Kinsella (1976)**.

Oil absorption capacity (OAC) of flours was determined by the method of **Sosulski *et al.*, (1976).**

Free gluten biscuits: The biscuits were prepared with slight modification in standard method of **AACC (2010).**Quinoa seeds flour was used to replace 25, 50, 75 and 100% of flour (by weight).

Physical properties of biscuits: Diameter of biscuit was measured by laying six biscuits edge to edge with the help of a venire caliper. Biscuits were rotated 90° and re-measured to obtain average diameter according to **AACC (2010).**

Thickness (T) or height of biscuits was measured with a venire caliper by taking average thickness (T) of six biscuits in cm. **AACC (2010)**

Spread ratio was calculated according to **AACC (2010)** by dividing the average value of diameter by average value of thickness of biscuit.

Weight, volume and specific volume: Average weight of 5 biscuit was measured. Volume of the biscuits was measured in cm^3 by rape seed displacement. Specific volume was calculated by dividing the volume (in cm^3) by weight (in g) according to **AACC (2010).**

Sensory evaluation: The biscuit samples were assessed for their quality attributes after baking according to the method which was described by **Manohar and Rao (1997)**

Statistical analysis: The Statistical analysis was carried out using ANOVA with two factors under significance level of 0.05 for the whole results using SPSS (ver. 22). Data were treated as complete randomization design according to **Steel *et al.* (1997)**. Multiple comparisons were carried out applying LSD.

Results and Discussion

Experimental treatments and technological processing:

Physical properties of quinoa seeds:

The knowledge of the morphology and size distribution of quinoa seeds is essential for the adequate design of the equipment for cleaning, grading and separation **(Kachru *et al.*, 1994).**

Physical properties of quinoa seeds(*Chenopodium quinoa*Willd.) are showed in Table (1), it could be noticed that the 1000-seed weight of quinoa seed was 2.708g which indicating that quinoa which cultivated in Egypt is similar to the result with obtained by **Bhargava*et al.*, (2007)** who found that the 1000-seed weight of quinoa seed was 2.69g. Also,these results are inagreement with that published by **Bhargava*et al.*, (2006)** who found that for 17 cultivars of quinoa, 1000-seed weight ranged from 1.99 to 5.08g.

Table 1. Physical properties of quinoa seeds (mean±SE).

Parameters	Values
1000-seed weight(g)	2.71±0.002
Bulk density(g/m^3)	0.80±0.0015
Test Weight (kg/100L)	75.64±0.021
Diameter of seed(mm)	1.99±0.015

Also, it is well known that, bulk density determines the capacity of storage and transport systems; the bulk density value of quinoa seed was 0.8g/m^3. However, quinoa seed produces small, circular-shaped seeds, about (1.8-2mm) diameter these results are supported by **Vilche *et al.*, (2003).**

Functional properties of quinoa seeds flour

Some functional properties of quinoa seeds flour and of each components of quinoa seeds flour are described and shown in Table (2).

Water absorption index (WAI) and water solubility index (WSI) are important physical characteristics affecting the quality of manufactured foods. WAI and WSI of quinoa seeds flour are presented in Table (2) and were to be found 3.01g of water/g of quinoa seeds flour and 4.64%, respectively.

An increase of water absorption index could be ascribed to an increase in protein content **(Gamel*et al.*, 2006).**These results were confirmed by **Abugoch*et al.* (2009)** whoreported thatWAI of quinoa seeds flour ranged from 2.3 to 4.5g/g.

The WSIof quinoa seeds flour was5.64%; it was higher than that reported by**Rodriguez-Sandoval *et al.*, (2012)** which equaled 5.10%.

The gelatinization causes an increase of the swelling powerparameter as shown in Table (2) that provides evidence ofthe magnitude of interaction between starch chainswithin the amorphous and crystalline domains. Swelling power was 2.56 of quinoa seeds flour which are in agreement with that published by **Rodriguez-Sandoval *et al.*, (2012).**

Table (2) showed that the oil absorption capacity (OAC) of quinoa seeds flour was 1.44%. This result indicated that quinoa seeds flour showed lower OAC in comparison with wheat flour (1.69 g/g) and buckwheat flour (1.80 g/g) but higher than amaranth flour (1.04 g/g) **(Chauhan *et al.*, 2015 and Kaur*etal.*,2015).**

The value of bulk density of quinoa seeds flour was 0.72 g/100ml. These results are in accordance with that reported by **Vilche *et al.*, (2003)**.

Table 2. Functional properties of quinoa seeds flour (mean±SE).

Functional properties	Values
Water absorption index (WAI) (g/g)	3.01±0.002
Water solubility index (WSI) (%)	5.64±0.010
Swelling power (SP)	2.56±0.012
Oil absorption capacity (OAC) (%)	1.44±0.015
Bulk density (BD) (g/100ml)	0.72±0.003

Proximate chemical composition of quinoa seeds flour

Moisture, protein, fat, crude fiber, ash, carbohydrates and total calories for quinoa seeds flour were determined. The obtained results are presented in Table (3). The obtained data indicates that quinoa seeds flour contained 9.461% moisture, 13.545% crude protein and 3.453% fat. These results are in agreement with those reported by **Valencia and Serna(2011)** who found that quinoa seeds flour had moisture, protein and fat contents equaled10.08, 13.96 and 4.69%, respectively. Also, the data obtained are in agreement with that reported by **Ogungbenle *et al.*, (2009) and Vidueiros *et al.*, (2015)**.

Also, the achieved data indicated that quinoa seeds flour contain a high amount of carbohydrates (63.555%) which are in agreement with those results reported by **Coda*et al.* (2010)and Elgeti*et al.*, (2014)**.

While, the values of crude ash and crude fiber were 2.686 and 7.299%, respectively; which agree the results reported by **Lamacchia *et al.*,(2010)**.

On the other hand, caloric value was calculated related from the decrease in fat and carbohydrates levels, which equaled 339.48kcal/100g

Table 3. Composition of quinoa seeds flour by g/100g (mean±SE)

Components	Percentage g/100g
Moisture	9.46±0.22
Crude protein	13.55±0.35
Crude fibers	7.30±0.12
Ash	2.69±0.30
Fat	3.45±0.20
Total carbohydrates*	63.56±0.48
Caloric value(kcal/100g)	339.48

*calculated by difference.

Minerals compositions of quinoa seeds flour

Table (4) shows the minerals content of quinoa seeds flour. It has been observed that the main minerals were potassium, phosphorus, and magnesium, their values were 8819.73, 4112.83and 1987.23 mg/kg, respectively. Also, quinoa had a high content of calcium (928.73 mg/kg), iron (149.407 mg/kg), and zinc (62.55mg/kg). On the other hand, sodium, manganese and cupper were found to be154.38, 18.483 and 55.97mg/kg, respectively. From these results, potassium was found to be the most abundant mineral, while copper was the least abundant. These results are in close agreement with the observation reported by **Palombini *et al.* (2013) and Gordillo-Bastidas *et al.* (2016).**

Table 4. Minerals content of quinoa seeds flour (mg/kg) (mean±SE)

Macro elements	Quinoa seed flour (mg/kg)	Micro elements	Quinoa seed flour (mg/kg)
P	4112.83±1.91	Fe	149.41 ±1.43
Ca	928.73 ±1.75	Cu	55.97 ±0.14
K	8819.73 ±0.75	Zn	62.55 ±1.10
Na	154.38 ±1.42	Mn	18.48 ±0.55
Mg	1987.23 ±1.28		

Vitamins content of quinoa seeds flour

Table (5) shows vitamin B1, B2, B3 and B6contents in the quinoa seed flour. Vitamin B3 content was the highest (0.992mg/100g), followed by B1 (0.481mg/100g) and B2 (0.0897mg/100g). Also, quinoa seed flour is considered as a good source of vitamin B6 (0.487mg/100g), vitamin C (16.219mg/100g) and folate (0.183mg/100g). As shown in Table (5), quinoa seed flour vitamin E content was 2.578 mg/100 g^{-1}.

Similar levels of vitamin E were reported by **Arneja *et al.* (2015)** for quinoa seed flour with 2.6 mg/100 g; while, thiamine, riboflavin and vitamin c were 0.4, 0.2 and 16.4mg/100g, respectively.

Table 5. Vitamins content of quinoa seeds flour (mg/100g).

Vitamins	Quinoa seed (%)	vitamins	Quinoa seed (%)
Thiamine B1	0.481±0.003	Folate	0.1833±0.001
Riboflavin B2	0.0897±0.002	Vitamin C	16.219±0.005
Niacin B3	0.992±0.003	Vitmin E	2.583±0.005
Pyridoxine B6	0.487±0.001		

Amino acids composition in the quinoa seeds flour

Amino acids compositions in the quinoa seed flour are presented in Table (6). Amino acids composition of quinoa seeds flour indicated that the presence of 18 amino acids including 10 essential amino acids. Data showed that glutamic acid (13.18%) was the major amino acid in sample and it could be noticed that hisitidine, threonine, phenylalanine, tyrosine and isoleucine were the limiting amino acids.

The obtained results indicated that quinoa seed had a well-balanced amino acid composition. The results are supported by the results accomplished by**Stikic*et al.* (2012)** and **Escuredo*et al.* (2014).**

Valcárcel-Yamani and Lannes (2012) reported that if the average values in raw quinoa compared with those values in FAO/WHO/UNU, suggested patterns for adults, it can be seen that quinoa proteins have higher or adequate concentrations of the essential amino acids, since there is no deficiency of any essential amino acid. It could be concluded that the ranges of amino acid contents in quinoa are sufficient for adults.

The results of amino acid scores (AAS) of quinoa seeds flour are shown in Table (6). The results revealed that threonine (69.0) was the limiting amino acid for QF. However, the other amino acids gave higher scores, indicating that degree of excellence was tryptophan (91.8).

Similar results were obtained by **Abugoch (2009)** who reported that quinoa seeds flour showed a high chemical score.

Table 6. Amino acid content of quinoa seeds flour (g/100g protein)

Essential Amino acids	gm/100g protein	Amino acids score (AAS%)	FAO/WHO*(g/100g)	Nonessential Amino acids	(g/100g protein)
Isoleucine	2.87±0.031	71.75	4.0	Glutamic acid	13.18±0.021
Leucine	4.94±0.035	70.57	7.0	Aspartic acid	6.77±0.021
Lysine	4.67±0.012	84.91	5.5	Proline	4.37±0.031
Methionine	1.91±0.008	96.00	3.5	Alanine	3.024±0.004
Cystine	1.45±0.009			Serine	3.17±0.006
Phenylalanine+ Tyrosine	5.957±0.021	85.10	7.0	Glycine Arginine	4.38±0.012 9.28±0.02
Valine	4.12±0.0153	82.40	5.0		
Threonine	2.76±0.036	69.00	4.0		
Histidine	3.26±0.031	81.50	4.0		
Tryptophane	0.92±0.006	91.80	1.0		
Total essential amino acids	32.855			Total nonessential amino acid	44.174
Total amino acids	64.61				

*Food and nutrition board: Adapted from WHO/FAO/UNU (1973) suggested indispensable amino acid requirements for adults ('present estimates').

The obtained results are in agreement with those reported by **Bhargava*et al.* (2006).** The above-mentioned, results indicated that quinoa seeds flour is considered as one of the best protein concentrate sources and so that has potential as a protein substitute for food, fodder and in the pharmaceutical industry.

Fatty acids composition of quinoa seeds flour

Fatty acids compositions in quinoa seeds flour are presented in Table (7). The results indicated that quinoa seed flour contains a high content of nutritionally valuable unsaturated fatty acids, linoleic acid accounting for 54.2%, linolenic acid 6.3% and oleic acid 24.1% of total fatty acids. These results are in agreement with those results reported by **Hager*et al.* (2012)** who found that the linoleic acid, linolenic acid and oleic acid contents of quinoa seed were 52.68, 4.6 and 23.93%, respectively.

Also, data indicated that quinoa seeds fat contained 10.7% palmitic acid, 2.4% stearic acid and 2.3% vaccinic acid.

From the obtained data, it has been observed that quinoa seeds oil was rich in unsaturated fatty acids (86.9%), On the other hand, quinoa seeds had less amount of saturated fatty acids (i.e. 13.1%).

These results of quinoa seeds lipid are also in agreement with those reported by **Peiretti *et al.*, (2013).**

Table 7. Fatty acids composition of quinoa seeds flour (% of total fatty acids)

Fatty acids Components	(%)
Palmiticacid ($C_{16:0}$)	10.7
Stearic acid ($C_{18:0}$)	2.4
Oleic acid ($C_{18:1}$)	24.1
Vaccinic acid ($C_{18:1}$)	2.3
Linoleic acid ($C_{18:2}$)	54.2
Linolenic acid ($C_{18:3}$)	6.3
Total saturated fatty acids (%)	13.1
Total unsaturated fatty acids	86.9

Nutritional values of quinoa seeds flour

The data of biological value (BV) and protein efficiency ratio (PER) are shown in Table (8).

Table 8. Biological evaluation of quinoa seeds flour

Parameters	Values
Biological value BV %	81.07
Protein efficiency ratio PER_A	2.73
Protein efficiency ratio PER_B	2.41
In vitro Protein digestibility (%)	81.30

The results of predicted BV revealed that quinoa seeds had a high value (81.07%), the PER_A and PER_B values were 2.73 and 2.41, respectively. The obtained results showed that predicted PER values of quinoa seed exceeded 2.00, which describe a protein of good to high quality. These results are in agreement with reported by **Schoenlechner *et al.* (2008).**

Biscuit from different blends of rice flour and quinoa seeds flours.

Quinoa seeds flour was used as a flour replacer in the production of different free gluten bakery products such as biscuits, crackers, cakes, and macaroni. The effect of different replacement levels were 25, 50, 75 and 100% on the sensory attributes, physical properties, and chemical composition of the resultant biscuits were studied.

Sensory evaluation of biscuits from different blends of rice flour and quinoa seeds flour.

Statistical analysis data for panelist scores of biscuits containing different levels of quinoa and rice flours were get to choose the best kind and concentration of quinoa seeds flour suitable for produces high quality and the means of sensory scores were given in Tables (9). No significant differences were observed in odor and appearance between control biscuits and those containing different levels of quinoa seeds flour.

Also, results showed that replacing up to 50% of rice flour in biscuits formula didn't have any significant ($P\leq 0.05$) effects on color, taste and texture of biscuits. A significant reduction of taste was observed when the quinoa seeds flour was increased to 100%. Biscuits prepared with replacing either of 50% of quinoa seeds flour or 75% of rice had overall acceptability which was not significant ($P\leq 0.05$) different when compared to the control biscuits. Biscuits with quinoa seeds flour replacement levels of 75% and 100% had significantly lowered overall acceptability when compared to the control biscuits but they were still of acceptable sensory characteristics.

In conclusion, it could be produced acceptable biscuits with 75 or 100% replacement with quinoa seeds flour. The accomplished results are in agreement with those obtained by **Lee *et al.*, (2009)**.

Table 9. Sensory evaluation of biscuits from different levels of quinoa seeds flours.

	Appearance	Color	Odor	Taste	Texture	Overall
Control	19.7^{a}	19.7^{a}	19.8^{a}	19.7^{a}	19.5^{a}	98.4^{a}
25%quinoa	19.7^{a}	19.7^{a}	19.7^{a}	19.8^{a}	19.2^{a}	98.1^{a}
50%quinoa	19.6^{a}	19.5^{a}	19.7^{a}	19.6^{a}	18.8^{ab}	97.2^{a}
75%quinoa	18.5^{b}	18.2^{b}	18.8^{ab}	18.1^{b}	18.3^{b}	91.9^{b}
100%quinoa	18.3^{b}	17.0^{c}	18.6^{b}	16.6^{c}	16.9^{c}	$87.^{c}$

Means within a column showing the same letters are not significantly different ($P \geq 0.05$).

Physical properties of biscuits from different blends of rice flour and quinoa seeds flour.

Physical properties, such as volume, weight, diameter and thickness of biscuits from different blends of rice and quinoa seeds flours are presented in Table (10). As the level of quinoa seeds flour increased, the volume of biscuits was decreased gradually. The results of measuring biscuits weights showed that the weight of flour replaced biscuits at 25 and 50% level of quinoa 8.51 and 8.91g, respectively, did not significantly different from the control one (8.49), while, it was significantly increased at higher and highest levels, i.e. 75 and 100% of quinoa seeds flour which were 8.96 and 9.01g, respectively. However, no significant differences were obtained in biscuits diameter between control sample and those contained different levels of quinoa seeds flour. Similar results were obtained by **Atef *et al.* (2014) and Păucean *et al.* (2015).**

These results indicated that the addition of quinoa seeds flour adversely effected on the thickness, diameter and spread ratio of the supplemented biscuits. These observations may be due that the weakness of gluten network. Biscuits having higher spread ratios are considered more desirable.

Table 10. Physical properties of biscuits from different levels of quinoa seeds flours.

Samples	Volume(cm^3)	Weight(g)	Specific volume	Diameter	Thickness	Spread
control	18.0^{a}	8.49^{d}	1.82^{a}	5.0^{a}	0.803^{a}	6.223^{d}
25%quinoa	17.28^{b}	8.51^{d}	1.80^{b}	4.97^{b}	0.787^{b}	6.322^{d}
50%quinoa	16.9^{c}	8.91^{c}	1.79^{c}	4.96^{c}	0.747^{c}	6.648^{c}
75%quinoa	16.7^{d}	8.96^{b}	1.77^{d}	4.93^{d}	0.667^{d}	7.39^{b}
100%quinoa	16.5^{e}	9.01^{a}	1.76^{cd}	4.92^{d}	0.577^{e}	8.532^{a}

Means within a column showing the same letters are not significantly different ($P \geq 0.05$)

Chemical analysis and caloric values of biscuits from different blends of rice flour and quinoa seeds flour.

Chemical analysis and caloric values of biscuits from different blends of rice flour and quinoa seeds flour are shown in Tables (11).

Gradual and significant (P≤ 0.05) increments in moisture contents of the resulted biscuits were observed with increasing the replacement levels of quinoa seeds flour. Biscuits prepared with replacement of 100% of quinoa seeds flour had moisture content of 4.79% compared to 4.16% for control sample. About similar results were obtained by **Păucean *et al.* (2015)**.

Protein contents of flour-replaced biscuits were higher than that of the control biscuits. Protein content of biscuits containing 75 and 100% quinoa seeds flour (11.14 and 11.61%) was higher than those of 25 and 50%quinoa seeds flour (8.77 and 9.97%). These results may be due to the high protein content of quinoa seeds flour compared to rice flour. Also about similar findings were obtained by **Alencar *et al.* (2015).**

Fat content was not significantly (P≤0.05) increased as the flour replacer level increased. This may be due to the high fat content of quinoa seeds flour (3.453%) compared to rice flour (0.6%). On contrast the trend of fat and protein content, a positive and increase in ash and crude fiber were obtained by increasing flour replacement level in biscuits. The crude fiber content of the biscuit samples was increased from 0.93% (control) to 4.68% as a result of replacement of 100% of rice with quinoa, respectively. Ash content showed a statistical different (P≤0.05), with the increasing of quinoa seeds flour as a flour replacer. This means that for more ash these are more mineral content. The nutritional quality of products depends on the quantity of product and quality of the nutrients. Therefore addition of quinoa seeds flour caused an increase in protein, ether extract, crude fiber ,ash and total dietary fiber and showed an increase in some mineral contents, such as Na, Ca and Fe contents **(Wafaa *et al*., 2015) and Brito *et al*., 2015).**

Table 11. Chemical analysis and caloric values of biscuits

Sample	Moisture	Protein	Fat	Ash	Crud	Carbohyd-	CaloriesValues
Control	4.16^{e}	7.31^{e}	26.53^{e}	1.32^{e}	0.93^{e}	59.76^{a}	507.01
25%quinoa	4.32^{d}	8.77^{d}	26.48^{d}	1.67^{d}	2.11^{d}	56.64^{b}	500.00
50%quinoa	4.57^{c}	9.97^{c}	26.70^{c}	2.08^{c}	3.42^{c}	53.26^{c}	493.22
75%quinoa	4.74^{b}	11.14^{b}	27.20^{b}	2.26^{b}	4.58^{b}	50.09^{d}	489.68
100%quinoa	4.79^{a}	11.61^{a}	27.52^{a}	2.91^{a}	4.68^{a}	48.49^{e}	488.08

Means within a column showing the same letters are not significantly different (P ≥0.05)
*calculated by difference

Concerning the total carbohydrates content, it tended to be a negative relationship with flour replacement level. Biscuits with 100% quinoa seeds flour had total carbohydrates (48.49%) compared of the control biscuits which had (59.76%). On the other hand, caloric value of biscuit samples was decreased by increasing the level of quinoa seeds flour, the calories for each 100g of biscuits was reduced from 507.01 of control biscuit to 488.08 with 100% of rice was replaced by quinoa. The caloric value is considered to be the caloric measure of interest to the consumer because it represents the actual caloric intake when consuming a 100g of fresh product. These results are very close to the data reported by **Păucean *et al.*, (2015).**

Hardness, acid value, peroxide value and antioxidant values of biscuits

Hardness (N) of biscuits containing different levels of quinoa seeds flour is presented in Table (12). A positive relationship has been observed between quinoa seeds flour replacement levels and the hardness of the biscuits. Addition of 25, 50, 75 and 100% of quinoa seeds flour caused significant increment in hardness of biscuits i.e. from 19.43N (in control sample) to 21.53, 25.43, 26.57 and 28.3N, respectively. The obtained results from the same table also revealed that biscuits prepared with 100% of quinoa seeds flour had significant higher hardness values than those prepared with the other levels. The achieved results are about similar to those obtained by **Bhaduri and Navder (2014)**.

Peroxide value of lipids extracted from the control sample at zero time was 2.67 meq/kg which didn't differ considerably from those of other variations, these ranged between 2.43 and 2.70meq/kg. While, the acid values ranged between 0.36 for control sample and 0.38 for biscuits with 100% quinoa seeds flour.

Quinoa seeds contain a large quantity of lipid that is high in unsaturated fatty acids. However, the fatty acids are highlystable this may be due to the presence of vitamin E, and other antioxidant. The antioxidant activity against the lipids in quinoa seed was high compared with wheat **(Asao and Watanabe, 2010**). Therefore, it has been suggested that quinoa contributes to the oxidative stability of food.

Quinoa seed is highly nutritious and rich in fiber, vitamins, and minerals. Consequently, the quinoa could be classified as a "functional food"because it provides many health benefits beyond its nutritional content.

Table 12. Hardness, acid value, peroxide value and antioxidant values of biscuits

Sample	Hardness	Acid value	Peroxide value	Antioxidant
Control	19.43[e]	0.356[c]	2.67[ab]	6.67[e]
25%quinoa	21.53[d]	0.37[b]	2.57[b]	17.22[d]
50%quinoa	25.43[c]	0.376[b]	2.43[c]	25.41[c]
75%quinoa	26.57[b]	0.39[a]	2.63[ab]	35.94[b]
100%quinoa	28.3[a]	0.376[b]	2.7[a]	51.33[a]

Means within a column showing the same letters are not significantly different ($P \geq 0.05$)

References

A.A.C.C. (2010). Approved methods of the American Association of Cereal Chemists analysis. Published by the American Association of Cereal Chemists, St. Paul, MNY , USA

Abderrahim, F.; Huanatico, E.; Segura, R.; Arribas, S.; Gonzalez, M. C. and Condezo-Hoyos, L. (2015). Physical features, phenolic compounds, betalains and total antioxidant capacity of coloured quinoa seeds (*Chenopodium quinoa*Willd.) from Peruvian Altiplano. Food Chem., 183: 83–90.

Abugoch, L.; Castro, E.; Tapia, C.; Añon, M.C.; Gajardo, P. and Villaroel, A. (2009). Stability of quinoa flour proteins (*Chenopodium quinoa* Willd.) during storage. Inter.J. Food Sci. Technol., 44: 2013-2020.

Abugoch, L.E. (2009). Quinoa (*Chenopodium quinoa* Willd.): composition, chemistry, nutritional, and functional properties. Advanced Food Nutr. Res., 58: 1–31.

Aksson, W.R. and Stammann, M.A. (1983). A pepsin pancreatin digest index of protein quality evaluation. J. Nutr., 64:257-261.

Alencar, N.M.M.; Steel, C.J.; Alvim, I.D.; Morais, E.C. andBolini, H.M.A. (2015). Addition of quinoa and amaranth flour in gluten-free breads: Temporal profile and instrumental analysis. J. Food Sci. Technol., 62: 1011-1018.

Alsmeyer, R.H.; Cunningham, A.D. and Happich, M.L. (1974). Equations predict PER from amino acid analysis. Food Technol., 28:34-38.

Alvarez-Jubete, L.; Arendt, E.K. and Gallagher, E. (2010). Nutritive value of pseudo-cereals and their increasing use as functional gluten-free ingredients. Trends Food Sci. Technol., 21(2): 106–113.

Anderson, R. A.; Conway, H. F. and Griffin, E. L. (1969). Gelatinization of corn grits byroll and extrusion cooking. Cereal Sci., 14: 4-12.

A.O.A.C. (2010). Official Methods of Analysis of the Association of Official Analytical Chemists, 19th ed., (Ed. Horwitz, W.). Washington.

Arneja, I.; Tanwar, B. and Chauhan, A. (2015). Nutritional Composition and Health Benefits of Golden Grain of 21st Century, Quinoa (*Chenopodium quinoa willd.*): A Review. Pakistan J. Nutr., 14(12): 1034-1040.

Asao, M. and Watanabe, K. (2010). Functional and bioactive properties of quinoa and amaranth. J. Food Sci. Technol. Res., 16: 163-168.

Atef, A.; Abou-Zaid; El-Faham; S.Y.; Wafaa and Emam, H. (2014). Use of Quinoa Meal to Produce Bakery Products to Celiac and Autism Stuffs. Inter. J. Sci. Res., 3(9): 1344-1354.

Bhaduri, S. and Navder, K.P. (2014). Freeze Dried Blueberry Powder Fortification Improves the Quality of Gluten Free Snacks. Food Process Technol., 5(12): 1-7.

Bhargava, A.; Shukla, S. and Ohri, D. (2006).*Chenopodium quinoa* an Indian perspective. Ind. Crop. Prod, 23: 73-87.

Bhargava, A.; Shukla, S.; Rajan, S. and Ohri, D. (2007). Genetic diversity for morphological and quality traits in quinoa (*Chenopodium quinoa*Willd.) germplasm. Genetic Resources Crop Evolution, 54:167–173.

Brito, I. L.; Souza, E. L.; Felex, S. S. S.; Madruga, M. S.; Yamashita, F. andMagnani, M. (2015). Nutritional and sensory characteristics of gluten-free quinoa(*Chenopodium quinoa* Willd)-based cookies development usingan experimental mixture design. J. Food Sci. Technol., 52(9):5866–5873.

Chauhan, A.; Saxena, D. C. and Singh, S. (2015). Total dietary fibre and antioxidant activity of gluten free cookies made from raw and germinated amaranth (*Amaranthus spp.*) flour. J. Food Sci. Technol., 63(2): 939-945.

Coda, R.; Rizzello, C.G. and Gobbetti, M. (2010). Use of sourdough fermentation and pseudo-cereals and leguminous flours for the making of a functional bread enriched of γ-aminobutyric acid (GABA). Inter. J. Food Microbiol., 137: 236–245.

Collado, L. S.; Mabesa, L. B.; Oates, C. G. andCorke,H. (2001). Bihon-type noodles from heat-moisture-treatedsweet potato starch.J. Food Sci., 66(4): 604-609.

Eggum, B.O.; Villegas, E.M. and Vasal, S.K. (1979). Progress in protein quality of maize.J. Sci. Food Agric., 30: 1148-1153.

Elgeti, D.; Nordlohne, S.D.; Föste, M.; Besl, M.; Linden، M.H.; Heinz, V.;Jekle, M. and Becker, T. (2014). Volume and texture improvement of gluten-free bread using quinoa white flour.J. Cereal Sci., 59(1): 41-47.

Eneche, E.H. (1999). Biscuit-making potential of millet/pigeon pea flour blends. Plant Foods Human Nutr., 54: 21-27.

Escuredo, O.; Martín, M.I.G.; Moncada، G.W.; Fischer, S. and Hierro, J.M.H. (2014). Amino acid profile of the quinoa (*Chenopodium quinoa* Willd.) using near infrared spectroscopy and chemometric techniques.J. Cereal Sci., 60(1): 67-74.

FAO/WHO (1973). Energy and protein requirements. Reports of FAO Nutrition Meetings. Report Series No. 52, FAO, Rome, 118 p.

Fischera, S.; Wilckensa, R.; Jara, J. and Arandac, M. (2013). Variation in antioxidant capacity of quinoa (*Chenopodium quinoa* Will) subjected to drought stress. Industrial Crops Products, 46: 341– 349.

Gamel, T.H.; Linssen, J.P.; Mesallam, A.S.; Damir, A.A. and Shekib, L.A. (2006). Seed treatment affect functional and antinutritional properties of amaranth flours.J.Sci. Food Agric., 86: 1095-1102.

Gloria, D. L. (2013). Determining Reference Test Weight per Bushel Value of Grains.Weights and Measures Connection, 4 (6): 1-4.

Gordillo-Bastidas, E.; Díaz-Rizzolo, D.A.; Roura, E.;**Massanés, T.and Gomis, R. (2016).** Quinoa (*Chenopodium quinoa*Willd), from nutritional value to potential health benefits: An integrative review. J. Nutr. Food Sci., 6(3): 1-10.

Hager, A.; Wolter, A.; Jacob, F.; Zannini, E. and Arendt, E.K. (2012). Nutritional properties and ultra-structure of commercial gluten free flours from different botanical sources compared to wheat flours.J. Cereal Sci., 56: 239-247.

Hirose, Y.; Fujita, T.; Ishii, T. and Ueno, N. (2010). Antioxidative properties and flavonoid composition of *Chenopodium quinoa* seeds cultivated in Japan. Food Chem., 119: 1300–1306.

Hougen, F.W. and Bodo, V. (1973). Extraction and methanolysis of oil from whole or crushed rapeseed for fatty acid analysis. J. Am. Oil Chem. Soc., 50: 230-234.

Jancurova, M.; Minarovicova, L. and Dandar, A. (2009). Quinoa – a Review. Czech J. Food Sci., 27(2): 71–79.

Joshi, D. C.; Das, S. K. and Mukherjee, R. K. (1993). Physical propertiesof pumpkin seeds. J. Agri. Eng.Res., 54(3): 219–229.

Kachru, R.P.; Gupta, R.K. and Alam, A. (1994). Physico-chemical Constituents and Engineering Properties of Food Crops. Scientific Publishers, Jodhpur. ISBN: 81-7233-083-9

Kaur, M.; Sandhu, K. S.; Arora, A. and Sharma, A. (2015). Gluten free biscuits prepared from buckwheat flour by incorporation of various gums: Physicochemical and sensory properties. J. Food Sci. Technol., 62: 628-632.

Lamacchia, C.; Chillo, S.; Lamparelli, S.; Suriano, N.; La Notte, E. and Del Nobile, M.A. (2010). Amaranth, quinoa and oat doughs: Mechanical and rheological behavior, polymeric protein size distribution and extractability. J. Food Eng., 96: 97–106.

Lee, A. R.; Ng, D. L.; Dave, E. E.; Ciaccio, E. J. and Green, P. R. (2009). The Effect of Substituting Alternative Grains in the Diet on the Nutritional Profile of the Gluten-FreeDiet.J. Human Nutri. Dietetics, 22(4): 359-363.

Manohar, R.S. and RaoO.H. (1997). Effect of mixing period and additives on the rheological characteristics of dough and quality of biscuits. J. Cereal Sci., 25: 197-206.

Miranda, M.; Vega-Gálvez, A.; Uribe, E.; López, J.; Martínez, E.; Rodríguez, M.J.; Quispe, I. and Di Scala, K. (2011). Physico-chemical analysis, antioxidant capacity and vitamins of six ecotypes of chilean quinoa (*Chenopodium quinoa*Willd). Procedia Food Sci., 1: 1439 – 1446.

Miranda, M.; Vega-Galveza, A.; Lopeza, J.; Paradac, G.; Sandersa, M.; Arandab, M.; Uribea, E. and Di Scalad, K. (2010). Impact of air-drying temperature on nutritional properties, total phenolic content and antioxidant capacity of quinoa seeds (*Chenopodium quinoa* Willd.). Industrial Crops Products, 32: 258–263.

Miranda, M.; Gálvez, A. V.; Fuentes, I. Q,; Rodríguez, M. J.; Maureira, H. and Martínez, E. A. (2012). Nutritional aspects of six quinoa (*Chenopodium quinoa*Willd) ecotypes from three geographical areas of Chile. Chilean J. Agri. Res., 72(2): 175-181.

Nascimento, A.C.; Mota, C.; Coelho, I.; Gueifão, S.; Santos, M.; Matos, A.S.; Gimenez, A.; Lobo, M.; Samman, N. and Castanheira, I. (2014). Characterisation of nutrient profile of quinoa (*Chenopodium quinoa*), amaranth (*Amaranthuscaudatus*), and purple corn (*Zea mays* L.) consumed in the North of Argentina: Proximates, minerals and trace elements. Food Chem., 148:420–426.

Nsimba, R.Y.; Kikuzaki, H. and Konishi, Y. (2008). Antioxidant activity of various extracts and fractions of *Chenopodium quinoa* and *Amaranthus spp.* seeds. Food Chem., 106: 760-766.

Ogungbenlel, H.N.; Oshodi, A.A. and M.O. Oladimeji, M.O. (2009). The proximate and effect of salt applications on some functional properties of quinoa (*Chenopodium quinoa*) flour. Pakistan J. Nutr., 8: 49-52.

Palombini, S.V.; Claus, T.; Maruyama, S.A.; Gohara, A.K.; Souza, A.H.P.; Souza, N.E.; Visentainer, J.V.; Gomes, S.T.M. and Matsushita, M. (2013). Evaluation of nutritional compounds in new amaranth and quinoa cultivars. J. Food Sci.Technol. (Campinas), 33(2): 339-344.

Păucean, A.; Man, S.; Muste, S. and Pop, A. (2015). Effect of quinoa flour addition on quality characteristics of rice gluten-free cookies. J. Agroalimentary Processes Technol., 21(4): 371-378.

Peiretti, P.G.; Gai, F. and Tassone, S. (2013). Fatty acid profile and nutritive value of quinoa (*Chenopodium quinoa*Willd.) seeds and plants at different growth stages. Animal Feed Sci. and Technol., 183: 56– 61.

Rodriguez-Sandoval, E.; Sandoval, G. and Cortes-Rodríguez, M. (2012). Effect of quinoa and potato flours on the thermomechanical and breadmaking properties of wheat flour. Brazilian J. Chem. Eng., 29(3): 503-510.

Schoenlechner, R.; Siebenhandl-Ehn, S. and Berghofer, E. (2008). Pseudocereals. In: Arendt, E.K., Dal Bello, F. (Eds.), Gluten-free Cereal Products and Beverages. Academic Press, Burlington, Massachusetts, pp. 149-176.

Sosulski, F. W.; Garratt, M. O. andSlinkard, A. E. (1976). Functional properties of tenlegume flours. Inter. J. Food Sci. Technol., 9: 66-69.

Steel, R.; Torrie, J. and Dickey, D. (1997): Principles and procedures of Statistics: A Biometrical Approach, 3rd ed., McGraw-Hill, New York, NY.

Stikic, R.; Glamoclija, D.; Demin, M.; Vucelic-Radovic, B.; Jovanovic، Z.; Milojkovic-Opsenica, D.; Jacobsen, S. and Milovanovic, M. (2012). Agronomical and nutritional evaluation of quinoa seeds (*Chenopodium quinoa*Willd.) as an ingredient in bread formulations. J. Cereal Sci., 55: 132-138.

Valcárcel-Yamani, B.andLannes, S.C.S. (2012). Applications of quinoa (*Chenopodium Quinoa*Willd.) and amaranth (*AmaranthusSpp.*) and their influence in the nutritional value of cereal based foods. Food Public Health, 2(6): 265-275.

Valencia, R.M.C. and Serna, L.A. (2011). Quinoa (*Chenopodium quinoa*, Willd.) as a source of dietary fiber and other functional components.Ciência e Tecnologia de Alimentos Campinas, 31(1): 225-230.

Valencia-Chamorro, S.A. (2003). Quinoa. In: Caballero B.: Encyclopaedia. Food Sci.and Nutr.,8: 4895–4902. Academic Press, Amsterdam.

Vega-Galvez, A.; Miranda, M.; Vergara, J.; Uribe, E.; Puenteb, L. and Martınez, E. A. (2010). Nutrition facts and functional potential of quinoa (*Chenopodium quinoa*Willd.) an ancient Andean grain. J. Sci. Food Agric., 90: 2541-2547.

Vidueiros, S.M.; Curti, R.N.; Dyner, L.M.; Binaghi, M.J.; Peterson, G.; Bertero، H.D. and Pallaro, A.N. (2015). Diversity and interrelationships in nutritional traits in cultivated quinoa (*Chenopodium quinoa*Willd.) from Northwest Argentina. J. Cereal Sci., 62: 87-93.

Vilche, C.; Gely, M. and Santalla, E. (2003). Physical Properties of Quinoa Seeds.Biosystems Eng., 86(1): 59–65.

Wafaa, K. G.; Zeinab, A. A. and Ali, R. G. (2015). Production of high dietary fiberbread fortified with quinoa flour. Adv. Food Sci., 37(2): 44-49.

Wang, J. C. and Kinsella, J. E. (1976). Functional properties of novel proteins: alfalfalead proteins. J. Food Sci., 41: 286-290.

Zhu, K.; Zhou, H. and Qian, H. (2006). Protein extracted from defatted wheat germ: Nutritional and structural properties. Cereal Chem., 83(1):69-75.

التقييم الغذائى والخواص الوظيفيه لدقيق الكينوا

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أجريت الدراسة لتقييم الخصائص الفيزيائية والكيميائية والغذائية والوظيفية لدقيق الكينوا. واظهرت النتائج ما يلى: بالنسبه للخصائص الفيزيائية وزن 1000 بذرة2.71 جم وقيم الكثافة الظاهرية0.80 جم/سم^2. اما بالنسبة لنتائج التركيب الكيميائي وجد أن دقيق الكينوا يحتوي على 13.55، 7.30، 2.69، 3.45 و 63.56٪ وذلك للبروتين الخام والألياف الخام والرماد والدهون والكربوهيدرات الكلية على التوالي. كما اظهرت النتائج ان الأحماض الأمينية لدقيق الكينواتتواجد فى صورة متوازنة خاصة الحمض الامينى ليسين (4.67جم/100جرام البروتين). أيضا يعتبرزيت الكينوا من الزيوت الغنية بالأحماض الدهنية غير المشبعة، كما لوحظ ان نسبه الاحماض الدهنيه غير المشبعة الى الاحماض الدهنيه المشبعة (86.9: 13.1).

من جهة أخرى وجد ان البسكويت المصنع باستبدال الارز بدقيق الكينوا خاصة عند نسبة استبدال 50أو 75٪ لا يختلف بدرجة معنوية عن البسكويت الكنترول (المصنع من 100% من الارز) خاصة فى القبولالعام.كما أظهرت الخواص الفيزيائية (الحجم والوزن والقطر والسمك) للبسكويت المصنع من خلطات مختلفة من دقيق الأرز والكينوا أنه كلما زادت نسبة الاستبدال بدقيق الكينوا انخفض حجم البسكويت تدريجيا. وعلى العكس أظهر التحليل الكيميائي وقيم السعرات الحرارية للبسكويت المصنع من خلطات مختلفة من الأرز ودقيق الكينوا أن البروتين والدهون والرماد والألياف الخام تزيد تدريجيا كلما زادت نسبة الاستبدال بدقيق الكينوا مقارنةبالعينه الكنترول .

كلمات البحث: الكينوا –دقيق الكينوا - البسكويت.