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Incorporation Quinoa and Chia Flour with Wheat Flour to Enhance the Nutritional Value and Improve the Sensory Properties of Pasta

Ragaa A. Sadeek , Areeg S. Aly * and Reham G. Abd Elsabor *

Abstract

With increase the food awareness of consumer, increased demand for products that have high nutritional value and provide health benefits by incorporation of new ingredients with the origin product. So, this study aimed to develop the pasta production formulation by using of mixture of wheat flour (WF) with chia flour (ChF) or quinoa flour (QF) at 20% or 40% and evaluating the chemical, nutritional, rheological, and sensory properties of the ideal pasta formula. The results were explained that ChF recorded higher content of protein, ash, fiber, and fat 16.56, 3.4, 8.95, and 33.43% respectively than WF and QF. Also, results confirmed the addition of ChF and QF contributed to the enrichment wheat pasta with energy and protein. Furthermore, ChF was recorded the highest content of energy 477.33 Kcal/100g compared with WF and QF. The consumption of 100g of pasta containing WF60% and ChF40% will cover the daily requirement of adult man for protein and energy, would be satisfied by 20.67 and 13.75% respectively. Water absorption and stability time was increased with increasing the levels of QF and ChF ratio in the dough, that due to increase the fibers content in QF and ChF, where

* Home Economics Department, Faculty of Specific Education, Minia University, Minia, Egypt .
*Corresponding Author: areeg_salama@mu.edu.eg

dough stability time were increased from 4.0 for WF control to 5.0, 6.5, 7.5 and 9.5 min for QF20%, QF40%, ChF20% and ChF40% respectively. Results were appeared differences in the sensory scores were highly significant ($p \leq 0.05$), particularly pasta formulas (WF60% + QF40%). On other hand, color, taste, and smell of pasta were differed from the WF control with the addition of 20 and 40% of ChF. In conclusion, this study recommended that the incorporation of chia and quinoa flour with wheat flour have beneficial effects for improving the chemical, nutritional, rheological, and sensory properties of food product pasta.

Keywords: Develop wheat pasta, functional ingredients, proximate chemical composition, rheological properties, sensory properties.

Introduction

In the world, pasta is consumed by individuals of all age groups where's considered a basic popular food quick to prepare by a low cost and have prefer sensory characteristics **(Wójtowicz and Mościcki, 2014; Oliviero and Fogliano, 2016 ; Biernacka *et al.*, 2017).** Improvements in the nutritional quality of pasta may occur through the incorporation of ingredients that increase protein content and also provide functional properties, such as fiber and antioxidants **(Zen *et al.*, 2020).** The nutrients and bioactive compounds are variety in quinoa and chia; also they can be incorporated as functional ingredients in a variety of food products **(Aly *et al.*, 2021; Fernández-López *et al.*, 2021).**

Quinoa *(Chenopodium quinoa,* L.) has received growing interest due to their exceptional nutritional value and potential health benefits**,** which seeds have high concentrations of nutrients and bioactive components making them ideal effective functional grains **(Goyat *et al*., 2018).** It is considered one of the best vegetal protein sources content ranges from 12.9 to 16.5%, that protein levels are similar to those found in milk and higher than those present in cereals as wheat, rice, and maize, also contains high value of an essential amino acids, that deficient in many legumes **(Vega-Gálvez *et al.,* 2010** ; **Meneguetti *et al.,* 2011** ; **Sánchez-Chino *et al.,* 2015** ; **Samira *et al.,* 2019)** and rich with lysine that is deficient in much grains **(Gesinski and Nowak, 2011** ; **Yang and Ludewig, 2014)**. It presents at least 23 phenolic compounds, contains more phenols than whole cereals as wheat and rice. The total phenolic content (mg/kg quinoa) is 466.99, 682.05 and 634.66 for white, black and red quinoa respectively, ferulic acid and quercetin are the most abundant phenols **(Ranilla *et al.,* 2009** ; **Repo-Carrasco-Valencia *et al.,* 2010** ; **Tang *et al.,* 2015).** QF is consider a good source of vitamins such as B3, B6, and B12 and has ideal amount of the minerals such as calcium, potassium, and magnesium **(El Sohaimy *et al.,* 2018**), the content oil varies from 2 to 10% and it had high amounted of the essential unsaturated fatty acids such as oleic, linoleic, and erucic acids **(Filho *et al.,* 2015** ; **Lamia and Mona, 2020**). Its functional products like a quinoa pasta, quinoa cereal and quinoa flakes have been known to have various health benefits and to be effective in cases of celiac disease, obesity, hypertension and cardiovascular diseases **(Alvarez-Jubete *et al.,* 2010).**

Chia (*Salvia hispanica,* L.) is an herbaceous plant seeds that has also been used for medicinal purposes for thousands of years and the word “chia” is meaning “oily” **(Coates, 2011; Munoz *et al.,* 2013** ; **Suri *et al.,* 2016).** It seeds are consumed as ingredients or additions to many foodstuffs: baked products, dairy drinks, fruit smoothies, salads and used as thickeners in soups and sauces **(Iglesias-Puig and Haros, 2013** ; **Inglett *et al.,* 2014** ; **Steffolani *et al.,* 2015).** Currently, it was attracted the attention of many groups of scientists and farmers due to its nutritional and functional characteristics (**Ayerza and Coates, 2011**), it contains high protein, dietary fiber includes lignin which contains antioxidant compounds and has some hypocholesterolemic effect **(Reyes-Caudillo *et al.,* 2008)** and have high content of lipid includes polyunsaturated fatty acids (PUFAs) (**Ixtaina *et al.,* 2011** ; **Uribe *et al.,* 2011).** Its oil contains a significant amount of PUFAs as omega-3 (75% of the total seed oil) and omega-6 fatty acids compared with other fruits and seeds **(Saldanha, 2004** ; **Biesalski *et al.,* 2009** ; **Ayerza and Coates, 2011**). Numerous studies confirmed that intake of food with high amounts of omega-3 leads to lower blood cholesterol and the risk of cardiovascular disease and are essential for brain function, management of arthritis and cancer **(Simopoulos and Cleland, 2003** and **Albert *et al.,* 2005)**. Its flour could be used as ingredients to enrich foods owing to their high amount of nutrients and the incorporation leading to increase the nutritional value of products in the proteins concentrations with higher biological value, minerals and lipids with a higher proportion of essential PUFAs **(Miranda-Ramos *et al.,* 2020).**

The objective of this study was to incorporation quinoa and chia flour with wheat flour to enhance nutritional value and improve the sensory properties of pasta**.**

Materials and Methods

Samples

Wheat flour 72%, chia, quinoa seeds and the rest ingredients were obtained from Aswaq Misr market, Minia City, Minia Governorate, Egypt.

Figure (1): Photo of (quinoa and chia) seed & flour

Chemicals

All chemicals used were of analytical grade and were obtained from AlGomhoria Company for Trading Drugs, Chemcal and Medical Instruments, Cairo, Egypt.

Methods

Preparation of quinoa and chia seed flour

According to (**Gaikwad *et al.*, 2021**) was selected a good kind of quinoa and chia, then cleaned to remove the unwanted material by used citric acid solution for 6 hours for removing bitterness of seed due to presence of saponins, washed with running tap water and then allowed to dry in the oven at 45°C for 12 hours. After drying, were ground in a high mixer blender (Toshiba ElAraby, Benha, Egypt) and sieved 750 µm mesh to obtain a quinoa flour 93% and chia flour 84%. Filled in glass jars and stored at 4°C until analysis and preparation the products.

Preparation fresh pasta

Was followed the techniques of preparation described by (**Torres *et al.*, 2021)** with some modifications in materials will clarified in table (1), and the method.

Table (1): Formulation of pasta

Ingredients (g)	T_0	T_1	T_2	T_3	T_4
WF	**100**	**80**	**60**	**80**	**60**
QF	**—**	**20**	**40**	**—**	**—**
ChF	**—**	**—**	**—**	**20**	**40**
Egg	**50**	**50**	**50**	**50**	**50**
Oil	**2**	**2**	**2**	**2**	**2**

T0: Control 100%WF **T1**: W F 80% + QF 20% **T2**: W F 60% + QF 40%
T3: W F 80% + ChF 20% **T4**: W F 60% + ChF 40%

Mix the ingredients first wheat flour, eggs and oil, then knead for 10 minutes. Secondly, cut the dough on a manual pasta machine into cylindrical shapes of 2 mm thick and cut into pasta with 30 cm length and 0.5 cm width, follow the same steps with the rest of the pasta produced from different blends of quinoa and chia flour with wheat flour, figure (2). The fresh pasta was put on trays for dried for 2 hours at room temperature and then kept in the refrigerator for 12 hours, then cooked in steam for 5 minutes.

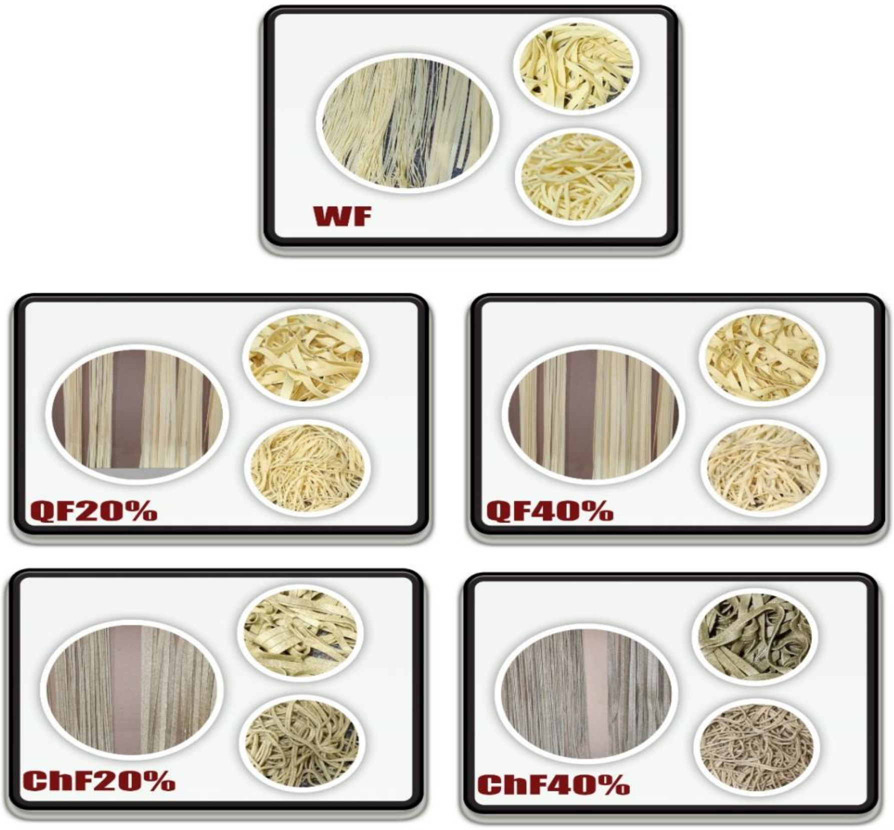

Figure (2): Photo of fresh pasta

Proximate chemical determinations

Moisture, fiber, ash, fat, and protein contents were determined according to **(AOAC, 2005)**. Carbohydrate content was calculated by the following equation:

Carbohydrate (%) = 100 – (Fat + Moisture + Fiber + Ash + Protein)

The energy content estimated using the following equation:

Energy value (kcal /100 g) = (4 {protein % + carbohydrate %} + 9{fat %}).

Determination of Water Holding Capacity (WHC) and Oil Holding Capacity (OHC)

To determine WHC and OHC of the WF, QF, and ChF were used the method described by (**Giami *et al.*, 1994)**, WHC and OHC are calculation after weighed the residues obtained after centrifugation.

Determination of physical properties of dough

Farinograph and Extensograph measurement

According to (**AACC, 1983** and **ICC, 1992)** methods, were examined the dough mixing properties of different wheat, quinoa, and chia flour blends by used the Brabender Farinograph, then extensograph test was carried out on a Brabender Extensograph (Brabender, Duisburg, Germany) to determine the maximum resistance to extension extensibility and strength of the dough (energy).

Evaluation of sensory properties of pasta

Sensory evaluation was conducted out with 20 panel tests at Home Economics Department, Faculty of Specific Education, Minia University. Prior to testing, the products were coded with a number and each panel tests received 5 pasta samples in a sealed pouch coded with different numbers. All panelists were evaluating taste, odor, color, texture, and overall acceptance to the products using the scores scale 1-10.

Ethical approval

All experiments for this study especially the sensory evaluation ones were ethically approved by Scientific Research Ethics Committee (SREC) Faculty of Specific Education, Minia University, Minia, Egypt.

Statistical analyses

Data were analyzed with GLM (General le\Linear Model) program using statistical analysis system **(SAS, 2003)**. Mean values were compared by Duncan's Multiple Test.

Result and Discussion

Proximate chemical of wheat and composite flours

The proximate analysis of WF, QF, and ChF are showed in Table (2). Results showed that moisture content varied from 9.83, 11.32 and 9.97 % for WF, QF and ChF respectively, and indicated that ChF had high content of fiber, ash, and protein content 8.95, 3.40 and 16.56 % respectively compare with WF and QF. This data in near with **(Grancieri *et al.*, 2019)** reported that content of protein in chia seeds was 18-24%. In addition, the protein content of QF was 14.42%. This result was agreed with (**Toapanta *et al.*, 2016)** explained that quinoa seed was content 13% protein**.** Also (**Samira *et al.*, 2019)** confirmed that quinoa seed contains high quality protein.

Table (2): Proximate chemical composition ($g.100g^{-1}$) of WF, QF and ChF

Parameters	WF	QF	ChF
Moisture	9.83 ± 0.63^{b}	11.32 ± 0.35^{a}	9.97 ± 0.16^{b}
Total protein	10.65 ± 0.37^{c}	14.42 ± 0.35^{b}	16.56 ± 0.56^{a}
fat	1.36 ± 0.13^{c}	6.91 ± 0.41^{b}	33.43 ± 0.63^{a}
fiber	1.77 ± 0.01^{c}	4.67 ± 0.38^{b}	8.95 ± 0.07^{a}
Ash	1.77 ± 0.08^{c}	2.83 ± 0.19^{b}	3.40 ± 0.29^{a}
Carbohydrates	74.63 ± 0.93^{a}	59.84 ± 0.84^{b}	27.69 ± 0.18^{c}

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at $p \leq 0.05$.

On other hand, result shows the ChF have the highest value of fat content was 33.43% more than 15 times of WF 1.36%. While, ChF have the lowest value of carbohydrate content 27.69% compared with WF and QF 74.36 and 59.84% respectively. Our results were agreeing with **(Abugoch *et al.*,2009)** indicated that quinoa had a high nutritive value for carbohydrate, protein, and fiber (58.3, 13.5, and 9.5%) respectively.

The chemical analyses are significantly different in fat, fiber, ash, and protein content among the composite flours except for moisture content as shown in Table (3). The highest value of ash, protein, fat, and fiber content was recorded at sample ChF 40% was 2.42, 13.01, 13.85 and 5.3% respectively, while WF samples had the lowest content about 1.77, 10.65, 1.36 and 1.77% respectively. Data shows the substitution of wheat flour with QF and ChF resulted in an increased in all parameters . Also, chia and quinoa are good sources of plant protein and chia have a high nutritive value especially because their high contents of dietary fiber and fat **(El Sohaimy *et al.*, 2018** and **Kulczyński *et al.*, 2019).**

Table (3): Proximate chemical composition (g.100g^{-1}) WF and mixture with QF and ChF

Parameters	WF 100%	QF		ChF	
		20 %	40%	20 %	40%
Moisture	**9.83 ±0.63**	**10.13±0.57**	**10.42 ±0.51**	**9.86 ±0.47**	**9.90 ±0.32**
Total protein	**10.65 ± 0.37^{c}**	**11.40±0.36^{b}**	**12.16±0.35^{b}**	**11.83±0.29^{b}**	**13.01±0.27^{a}**
Fat	**1.36± 0.13^{e}**	**2.47±0.18^{d}**	**3.58±0.24^{c}**	**7.77±0.05^{b}**	**13.85±47^{a}**
Fiber	**1.77 ± 0.01^{c}**	**2.34±0.10^{bc}**	**2.92±0.16^{b}**	**3.2±0.07^{b}**	**5.3±0.93^{a}**
Ash	**1.77 ±0.08^{d}**	**1.98±0.09^{c}**	**2.19±0.11^{b}**	**2.09±0.06^{bc}**	**2.42±0.10^{a}**
Carbohydrates	**74.63 ± 0.93^{a}**	**71.68±0.87^{b}**	**68.72±0.85^{c}**	**65.25±0.77^{d}**	**55.52±1.66^{e}**

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

Nutritional evaluation of WF and mixed with QF and ChF

Recommended daily allowances for energy represent the average needs of individuals from calories, if energy intake is consistently below or above a person's requirement, changes in body composition or body weight will occur and may adversely affect health **(NRC, 1989).** The nutritional evaluation of wheat flour, quinoa flour and chia flour were investigated in Table (4). Chia flour was recorded the highest content of energy and protein were 477.33 Kcal/100 g and 16.56g respectively, compared with WF and QF.

Table (4): Nutritional evaluation of WF and selected flour samples (QF and ChF)

Nutritional evaluation	RDA (1989)	WF	QF	ChF
Energy(Kcal/100g)	2900 Kcal	353.35±2.04[c]	359.26±0.65[b]	477.33±3.42[a]
*G.D.R. (g)		820.75±4.74[a]	807.22±1.46[b]	608.2±4.58[c]
**P.S./100 g		12.18±0.07[c]	12.39±0.02[b]	16.45±0.12[a]
Total protein	63 g	10.65±0.37[c]	14.42±0.35[b]	16.56±0.56[a]
G.D.R. (g)		592.27±20.55[a]	437.05±10.63[b]	380.86±12.6[c]
P.S./ 100 g		16.91±0.60[c]	22.89±0.55[b]	26.29±0.89[a]
Dry matter (%)		90.17±0.63[a]	88.68±0.35[b]	90.05±0.16[a]

* G.D.R. (g): Grams consumed to cover the recommended daily allowance of adult man according to RDA (1989). ** P.S. /100 (%): Percent satisfaction of RDA of adult man when consuming 100g of corn flour, chia and quinoa flour. Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

Similar studies explained the nutritional value for wheat flour fortified with chia seeds (**Hafeez *et al.*, 2019** and **Guiotto *et al.*, 2020)**. Results are agreed with (**Alamri, 2020)** reported that protein content in each 100 g chia seed was around 17 g that equal to nearly 30% of the recommended daily allowance for adults. Data in Table (4) it observed that the grams daily of energy which required obtaining RDA ranged from 608.2 g ChF, 807.22 g QF to 820.75 g WF. The consumption of 100 g ChF, QF and WF will cover 16.45, 12.39 and 12.18 % respectively of RDA of in energy according to RDA, (1989), while taking the same amount of ChF, QF and WF will cover will almost cover 26.29, 22.89 and 16.91% respectively of RDA in protein.

Table (5) presents the results of the nutritional evaluation of WF and blend with QF and ChF by different levels 20 and 40%, mix led to increase the value of the energy and total protein compare with WF. Pseudo cereals quinoa and chia seeds are rich in nutrients like fat, dietary fiber and non-conventional of protein which free- gluten to overcome celiac diseases **(López *et al.*, 2018; Thakur and Nimbalkar, 2020).**

Table (5): Nutritional evaluation of WF and mixture with QF and ChF

Nutritional evaluation	RDA (1989)	WF	QF		ChF	
			20%	40%	20%	40%
Energy(Kcal/100g)	2900 Kcal	353.35±2.04^{c}	354.59±1.43^{c}	355.74±0.92^{c}	378.26±2.28^{b}	398.83±1.69^{a}
*G.D.R. (g)		820.75±4.74^{a}	817.87±3.30^{a}	815.21±2.10^{a}	766.69±4.64^{b}	727.15±3.09^{c}
**P.S./100 g		12.18±0.07^{c}	12.23±0.50^{c}	12.27±0.03^{c}	13.04±0.07^{b}	13.75±0.06^{a}
Total protein	63 g	10.65±0.37^{c}	11.40±0.36^{b}	12.16±0.35^{b}	11.83±0.29^{b}	13.01±0.27^{a}
G.D.R. (g)		592.27±20.55^{a}	553.02±17.41^{b}	518.53±15.14^{bc}	532.87±13.26^{b}	484.06±10.3^{c}
P.S./ 100 g		16.91±0.60^{c}	18.10±0.57^{b}	19.30±0.56^{b}	18.78±0.46^{b}	20.67±0.43^{a}
Dry matter (%)		90.17±0.63	89.87±0.57	89.58±0.51	90.14±0.47	90.11±0.31

* G.D.R. (g): Grams consumed to cover the recommended daily allowance of adult man according to RDA (1989). ** P.S. /100 (%): Percent satisfaction of RDA of adult man when consuming 100g of corn flour, chia and quinoa flour. Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

ChF, 40%, had the highest value of energy 398.83% compare with all parameters was ranged from 353.35, 354.59, 355.74 and 378.26% for WF, QF20%, QF40% and ChF 20% respectively. In addition, blend WF with 40 % ChF had highest value of protein 13.01% compare with all parameters. This result led to the high content of protein in ChF 16.56%, and confirmed that 40 % ChF can be included in food formulations as Protein source. Our results agree with (**Rabail *et al.*, 2022)** reported that the incorporation of chia flour increased the nutritional value with regard to the concentrations of proteins that contains a high concentration of the basic amino acid lysine which deficient in cereals with higher biological value that can serve beneficial against malnutrition.

Functional properties

Water-Holding Capacity (WHC) and Oil- Holding Capacity (OHC)

WHC and OHC values for WF, QF, and ChF have been shown in Table (6). Data has confirmed that when replacement, WHC values increased with increases of the level from QF and ChF as compared with WF, these results were similar to those observed for OHC. The results of the WHC value were 6.21, 8.11 and 9.06g water/g flour for WF, QF and ChF respectively, while the results of the OHC were as follows 2.83, 3.64 and 4.02 g oil/g flour for WF, QF, and ChF respectively. Also, **(Kinsella and Melachouris, 1976)** and **Heywood *et al.*, 2002)** explained that protein–water interactions are related to WHC or water-holding, therefore, the amount of protein within samples may influence the WHC values. In general, results showed that WHC values were greater in all flour blends than WF, which may be due to its high fiber content. Furthermore, (**Noor *et al.*, 2012** ; **Elhassaneen *et al*., 2018)** reported that dietary fiber is able to bind or entrap more water than WF and the high WHC of fiber rich flour is attributed to the higher number of hydroxyl groups found in the fiber structure, which tends to allow more water interactions through hydrogen bonding.

Table (6): Functional properties (WHC and OHC) for different flour samples

Parameters	WHC	OHC
Samples		
WF 100%	**6.21 ±0.18^{c}**	**2.83 ± 0.20^{c}**
Q F 100%	**8.11 ±0.37^{b}**	**3.64 ± 0.06^{b}**
ChF 100%	**9.06 ±0.18^{a}**	**4.02 ±0.14^{a}**
WF 80% + Q F 20%	**6.59±0.09^{c}**	**2.99±0.17^{ab}**
WF 60% + Q F40%	**6.97 ±0.08^{b}**	**3.15±0.13^{ab}**
WF80% + Ch F20%	**6.60 ±0.15^{c}**	**3.07±0.19^{ab}**
WF 60% + Ch F 40%	**7.35 ±0.05^{a}**	**3.31±0.18^{a}**

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

The OHC of WF showed significant differences from QF and ChF, where all samples were found to be higher than WF 2.83. This is due to the presence of protein, which is a hydrophobic substance that provides more sites for holding the oil **(Heywood *et al.*, 2002)**.

Rheological properties of wheat flour and composite flours

Farinograph test

The results of all farinograph parameters for WF as control and WF with replaced by QF and ChF were presented in table (7) and figure (3) shows farinograph curves derived from wheat, quinoa and chia flour blends. Water absorption is important to determine texture and dough performance during baking, which represents a target water to flour ratio in dough **(Abera *et al.*, 2017)**. Data shows with increase the levels of QF and ChF the water absorption values were increased ratio in the dough (63.5, 64.0, 65.0, 66.0 and 67.0 for control, QF20%, QF20%, ChF20% and ChF40% respectively, that due to increase the fibers content in QF and ChF. Results are agreed with (**Ognean *et al.*, 2011**) confirmed that the fibers content led to higher water absorption of dough in different proportion are depending on their sources.

In addition, different researchers reported that the dough prepared from composite flours absorbed more water than from wheat flour only **(Lee *et al.*, 2001** ; **Morita *et al.*, 2002** ; **Elhassaneen *et al.*, 2014** ; **Elhassaneen *et al.*, 2016).** The reason for higher absorption ability might be a higher protein content in all studied flour mixtures **(Ribotta *et al.*, 2005),** be-sides the higher protein content, higher dietary fibers in the mixtures may be responsible for higher absorption properties.

Table (7): Farinograph parameters of WF and composite flours

Parameters	**WF 100%**	**QF**		**ChF**	
		20 %	**40%**	**20 %**	**40%**
Water absorption (%)	63.5	64.0	65.0	66.0	67.0
Arrival time (min)	1.2	2.27	2.39	2.32	3.08
Dough development time (min)	2.5	2.56	3.84	2.68	3.92
Stability Time (min)	4.0	5.0	6.5	7.5	9.5
Degree of Softening (B.U)	80	110	150	150	170

Dough development time is the time from first addition of water to that of maximum consistency immediately before first indication of weakening **(Abera *et al.*, 2017)**. Results in table (7) and figure (3) shows an increased in dough development time when add 20% of QF or ChF to 2.56, 2.68 min respectively, also, when add 40% of QF or ChF to 3.84 and 3.92 min respectively compared to WF 2.5 min as a longer relaxation time. These results might be associated with increasing content of protein and crude fiber in quinoa (**Sarabhai and Prabhasankar, 2015)** and chia flour (**Orona-Tamayo *et al.*, 2017)**. Also**,** results indicated that the dough stability time were increased from 4.0 for WF control to 5.0, 6.5, 7.5 and 9.5 min for QF20%, QF40%, ChF20% and ChF40% respectively, stability of dough increase with increasing QF and ChF levels. The stability time is the gluten quality parameter and is an indicator of the strength, with higher values suggesting stronger dough **(Rossel *et al.*, 2001** ; **Hallen *et al.*, 2004)**.

The degree of softening was increased with increasing the levels of addition, it could be noticed that the addition of 40% ChF had the highest degree of softening compared with wheat control and other samples. On other hand, 20% QF had the lowest degree of softening compared with wheat control and other samples

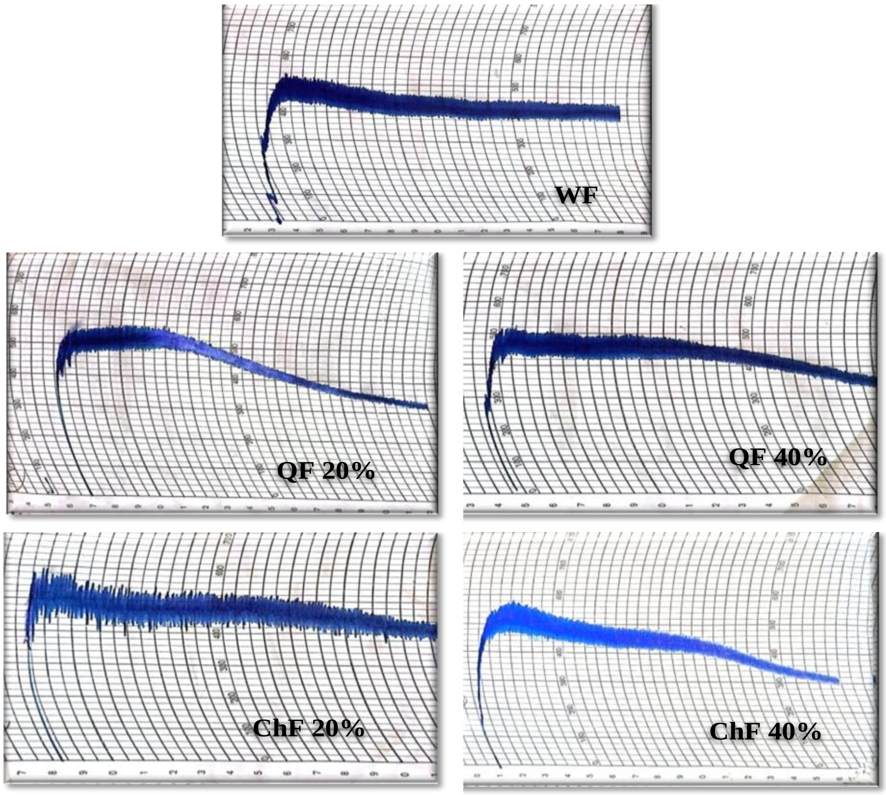

Figure (3): Effect of addition WF with QF and ChF at level 20 and 40% on the farinograph parameters of dough

Extensograph test

From Table (8) and figure (4), it could be noticed that addition of QF and ChF to WF lead to dough strength specific extensibility by the region under the curve and proportional to an energy required to cause rupture. The mixing in dough, increased the extensibility from 112 mm for control to 156 &162 mm and 165 & 168 for dough contained 20% and 40 % (QF and ChF) respectively. Also, noticed that the addition of QF and ChF were specimens exhibited substantially greater extension resistance than control samples from 360 for control to 480 & 515 and 508 & 750 for dough contained 20% and 40 % QF and Ch respectively. Dough expansion resistance is the most important measure of a dough's ability to hold gas. The addendum of QF and ChF to wheat flour cause increased energy from 103 to 115 & 130 and 126 &145 for wheat flour and dough contained 20% and 40 % QF and ChF respectively. The dough's extensibility is the dough's capacity to expand or stretch it relies on the proportion for gliadin throughout the dough (**El-Safy, 2013). Aly and Sadeek, (2018)** found incorporating of quinoa in dough increased the extensibility, relative, resistance to extension, proportional number, and energy for dough contained 10 and 20% of QS.

Table (8): Extensograph parameters of WF and composite flours

Parameters	**WF 100%**	**QF**		**ChF**	
		20 %	**40%**	**20 %**	**40%**
Extensibility (mm)	112	156	165	162	168
Elasticity (B.U)	360	480	508	515	750
P.N	2.27	2.93	3.6	4.27	10
Energy (Cm^2)	103	115	126	130	145

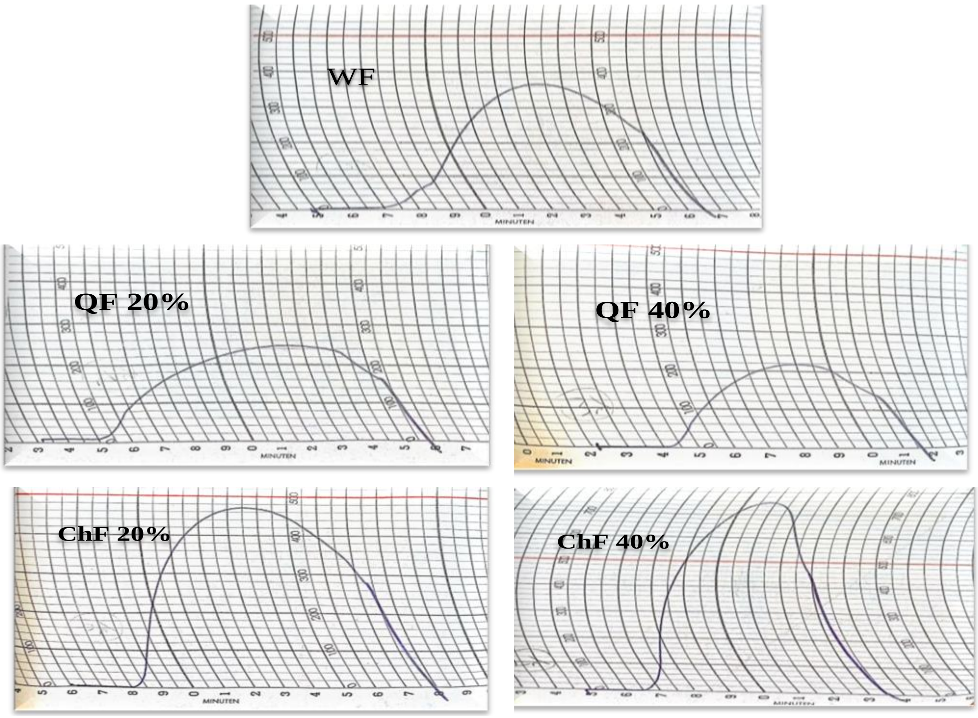

Figure (4): Effect of mix WF with QF and ChF at level 20 and 40% on the extensograph parameters of dough

Sensory evaluation of pasta

Table (9) and Figure (5), presents each attribute of the pasta sensory assessment made with QF and ChF were present significant differences than the control sample (WF) in sensory assessments**.** In general, the score of acceptability in color, odor, texture and taste was high. The sensory panelists reported that the sensory properties of the pasta control sample showed as pleasant odor and taste. However, pasta samples prepared with QF and ChF treatment were fine texture close to control sample.

Successful sensory estimate in food products is obtained by connecting nutrients and sensory properties to formulation which enables manufacturing food products with maximum consumer acceptance (**Sharif *et al.*, 2017)**. The degree of acceptance for the color and taste of the pasta made with QF and ChF was within acceptable limits, this response could be attributed to consumers expecting to see color and taste of pasta like conventional pasta.

Table (9): Sensory evaluation (degree) of pasta samples

Sensory properties / Samples	Color	Texture	Odor	Taste	Overall acceptability
WF 100%	9.80 ± 0.4[a]	9.25 ± 0.70	9.65 ± 0.48 [a]	9.30 ±0.78[a]	9.60± 0.49
WF 80% + Q F 20%	9.20 ± 0.68 [b]	9.25 ± 0.50	9.20±0.75 [a]	8.65± 1.11[b]	9.25±0.77
WF 60% + Q F40%	9.45 ± 0.67[ab]	9.05 ±0.67	8.60 ± 1.02 [b]	8.95± 0.92 [b]	9.30± 0.71
WF80% + Ch F20%	8.75 ± 0.99 [bc]	9.10 ± 0.7	9.40 ± 0.73[a]	8.75±0.89 [b]	9.15±0.57
WF 60% + Ch F 40%	8.60 ±1.02 [c]	9.05± 0.86	9.35± 0.73[a]	8.80± 0.87 [b]	9.20± 0.75

Each value represents the mean of twenty replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

Color is an important attribute of food choice and acceptance, for the value of color, sample prepared by QF (40%) had the highest color value (9.45) compared with samples prepared by ChF (10 and 20%) which had less score in terms of color (8.75 and 8.6) respectively, that is were significantly different from controls (9.8).

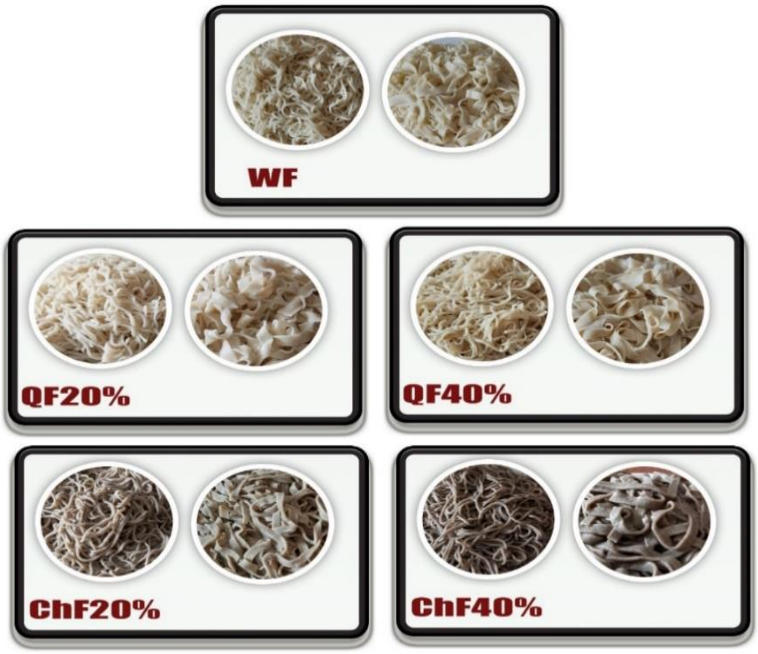

Figure (5): photo of pasta after cooking

The product might be likable without good taste, so this product is potentially to be unacceptable. Taste is a major parameter when evaluating the sensory properties of food products **(Muhimbula *et al.*, 2011).** For the value of taste, there was a significant difference between the control sample WF and other samples prepared with QF and ChF ($p \leq 0.05$). The samples QF and ChF 40% had taste value 8.95 and 8.80% respectively, while sample prepared by QF and ChF 20% had the lowest value of taste (8.65 and 8.75%) respectively. The samples with QF were more perfect than the samples with ChF and were found that increased levels of QF in pasta from 20 to 40% increased score of taste. Results are agreed with **(Torres Vargas *et al.*, 2021)** reported that the sensory assessment of pasta with quinoa flour could be considered a product of good acceptability by consumers. And it must be known that acceptability in products with quinoa can different from eating habits for age groups **(Ayseli *et al.*, 2020).**

Conclusion

This study have shown that chia and quinoa can be considered as a super food, they having high content of protein with a value of 16.56% and 14.42% respectively. In additional incorporated chia and quinoa flour with wheat flour is beneficial for improve the rheological and technological properties of products because of the higher nutritional values (protein, fiber, ash, fat and other antioxidant compound). For all these reasons, fortification wheat flour with quinoa and chia flour lead to improve the nutritional quality of pasta product without negatively affecting their sensory properties.

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خلط دقيق الكينوا والشيا مع دقيق القمح لتعزيز القيمة الغذائية وتحسين الخصائص الحسية للمكرونة

رجاء احمد صديق، أريج سلامة علي، ريهام جاد الرب عبد الصبور
قسم الاقتصاد المنزلي ، كلية التربية النوعية ، جامعة المنيا ، المنيا ، مصر
للمراسلة البريد الألكترونى: areeg_salama@mu.edu.eg

مع زيادة الوعي الغذائي للمستهلك، زاد الطلب على منتجات ذات القيمة الغذائية العالية والتى توفر العديد من الفوائد الصحية وذلك بخلط مكونات جديدة على المنتج الاصلى. لذلك هدفت هذه الدراسة إلى تطوير تركيبة إنتاج المكرونة باستخدام خليط دقيق القمح مع دقيق الشيا أو دقيق الكينوا بنسبة (20 و40٪)، وتقييم الخصائص التغذوية والحسية والريولوجية لتركيبة المكرونة المثالية. أوضحت النتائج أن دقيق الشيا قد سجل أعلى محتوى من البروتين والرماد والألياف والدهون (16.56 ، 3.4 ، 8.95 و33.43٪) على التوالي، مقارنة بدقيق القمح والكينوا، وأكدت النتائج أن إضافة دقيق الكينوا أو دقيق الشيا ساهم في إثراء مكرونة القمح بالطاقة والبروتين. كما أشارت البيانات إلى أن دقيق الشيا سجل أعلى محتوى للطاقة (477.33 سعر حرارى / 100 جم) مقارنة بدقيق القمح والكينوا وسيغطي استهلاك 100 جرام من المكرونة التي تحتوي على دقيق قمح 60 و40٪ دقيق الشيا الاحتياجات اليومية للشخص البالغ من البروتين والطاقة بنسبة (20.67 و 13.75٪) على التوالي. تمت دراسة تأثير إضافة دقيق الشيا والكينوا إلى دقيق القمح على الخصائص الطبيعية للعجين مثل إمتصاص الماء ووقت الثبات ووقت تطور العجين. أوضحت النتائج زيةادة وقت امتصاص الماء وثباته مع زيادة نسبة دقيق الكينوا و الشيا في العجين، وذلك بسبب زياد محتوى الألياف حيث زاد وقت ثبات العجين من 4.0 في دقيق القمح إلى 5.0 و 6.5 و 7.5 و 9.5 دقيقة لـ الكينوا 20٪ و 40٪ و الشيا 20٪ و 40٪ على التوالي. تم تقييم الخصائص الحسية للمكرونة وأظهرت النتائج اختلافات معنوية ($p \leq 0.05$) في الدرجات للسمات الحسية وخاصة تركيبه المكرونة (60٪ دقيق قمح 40+% دقيق كينوا). و من ناحية أخرى، مع إضافة 20 و 40٪ من دقيق الشيا اختلف لون وطعم ورائحة المكرونة عن عينة القمح الكنترول. توصي الدراسة بخلط دقيق الشيا والكينوا مع دقيق القمح لتحسين القيمة الغذائية والخصائص الريولوجية والتكنولوجية للمنتجات الغذائية.

الكلمات المفتاحية: تطوير المكرونة ، الدقيق المركب ، المكونات الوظيفية ، التركيب الكيميائى التقريبي ، الخصائص الريولوجية، الصفات الحسية.