Evaluation of quinoa (*Chenopodium quinoa Willd*) flour fortification on the quality of pasta production

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ABSTRACT

The aim of the present investigation was to formulate a pasta product with increased levels of protein and nutritive value by adding quinoa flour to traditional durum wheat semolina. And studding the effects of fortification on farinograph parameters, color characteristics, cooking quality, consumer acceptance, texture profile and chemical composition, and the most desirable ratio of quinoa flour is to be determined. Pasta was fortified with 10, 20 and 30% quinoa flour (QF) and evaluated against a control made of 100% semolina flour (control) for farinograph parameters, color characteristics, cooking quality, consumer acceptance, texture profile and chemical composition. Fortification pasta dough with QF at 10, 20 and 30% gradually increased water absorption, mixing tolerance index and dough weakening, meanwhile decreased the arrival time, dough development time and dough stability scores gradually comparing with those of pasta control sample. Pasta was darker and more brown in color (L and b* values decreased while a* values increased) with the increased addition of quinoa flour. Pasta products containing quinoa flour had an increased weight and volume than control gradually by increasing QF. Cooking loss of fortified pastas was significantly (p<0.05) greater than the control, but were within the acceptable range of 7-8%. The untrained consumer panel significantly (p<0.05) preferred the control pasta over those fortified with quinoa flour. All pasta variations were deemed acceptable in sensory study. Hardness of pasta increased as the percentage of quinoa fortification increased. Quinoa flour had adverse effects on protein, fat, ash and fiber content when compared to control. It can be recommended that fortification with different percentages of quinoa flour produces high nutritional value and high protein pasta.*

Keywords: *Pasta, Quinoa, Farinograph, Cooking quality, Hardness.*

INTRODUCTION

Quinoa, or *chenopodium quinoa*, is a member of the *Amaranthaceae* plant family. Although it is a flowering plant, quinoa's grass-like uses and qualities cause it to be considered a pseudo-cereal. Quinoa grains can be used for many things. They can be toasted, ground into flour, boiled and added to soup, or cooked and served similar to rice. Quinoa flour can be used to make pasta or breads. Unlike cereals, quinoa has a soft outer layer that does not need to be removed before milling. This allows quinoa to yield roughly 100% flour **(Fleming and Galwey 1995; Jacobsen, 2011; James, 2009 and Alvez *et al*., 2010).**

Studies have shown that quinoa is a good source of quality protein (10.4-17.0%), dietary fiber, polyunsaturated fats, and minerals (**FAO, 2014**). It has been found to contain between 10-21% protein, with most products averaging around 13% (**Fleming and Galwey, 1995; Bhargava *et al*., 2005)**. These fats are shown to maintain their quality due to the prevalence of vitamin E, a natural antioxidant (**Su-Chuen et al., 2007; Abugoch, 2009**).

Quinoa content is rich in vitamin A, B2, E and minerals such as calcium, iron, zinc, magnesium and manganese, which give the grains high value for different target populations: for instance, adults and children benefit from calcium for bones and from iron for blood functions (**Kozioł, 1992 and Repo-Carrasco *et al*., 2003**)

Quinoa has some functional (technological) properties like solubility, water-holding capacity (WHC), gelation, emulsifying, and foaming that allow diversified uses **(Gorinstein *et al*., 2008)**. Quinoa starch has physicochemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses (**James 2009**). There are several developments with quinoa flour at a smaller scale, like bread, cookies, muffins, pasta, snacks, drinks, flakes, breakfast cereals, baby foods, beer, diet supplements, and extrudates (**Linnemann and Dijkstra, 2002; Dogan and Karwe, 2003 and Bhargava *et al*., 2006**). **Nsimba *et al*. (2008)** used quinoa and amaranth in products such as bread, pastas and baby foods. The seeds are small and have been used as flour, toasted, added to soups, or made into bread. Quinoa is highly nutritive and is being used to make flour, soup, breakfast and alcohol. It is sold either as whole grain that is cooked as rice or in combination dishes **(Galwey, 1989)**.

Due to its low price, ease of preparation, stable shelf life, and overall versatility, pasta is consumed by many people worldwide. Having originated in Asia and the Mediterranean, Italy is still most well-known for its pasta making and leads in national consumer consumption per capita. The versatility of pasta allows it to be formed into almost any shape and size. It comes in varieties such as spaghetti, fettuccine, macaroni, rotini, and farfalle. It can even be stuffed with meats or cheeses to make ravioli. Pasta is prepared in two styles, fresh or dried. Fresh pasta eliminates the drying step and allows for a much quicker product to be made, but has only a portion of the shelf life of dried pasta (**Marconi and Carcea 2001; International Pasta Organization 2012**; **Savita *et al*., 2013**).

Pasta is a source of carbohydrates (74–77%, dry basis) with low glycaemic index (GI) (**Monge *et al* 1990**). Pasta also contains 11–15% proteins but is deficient in lysine and threonine (the first and second limiting amino acids), common to most cereal products (**Abdel-Aal and Hucl, 2002**). This provides an opportunity for the use of non-traditional raw materials to increase the nutritional quality of pasta (**Del Nobile *et al*., 2005**). Consequently, legumes and cereals are nutritionally complementary (**Duranti 2006**).

Aim of work: Therefore the present investigation was carried out to assess the pasta quality by enriching with quinoa seeds as a protein source.

MATERIALS & METHODS

Materials

Semolina (*Triticum durum*) was procured from the local market. Quinoa seeds (*Chenopodium quinoa* Willd.) were obtained from National Research Center, Giza, Egypt. The quinoa seeds were treated by washing and polishing to remove an outer coat containing bitter saponins **(Dini *et al*., 2002**). Then, seeds grinded until become soft powder.

Methods

Pasta preparation: Pasta samples were produced by hand in a homemade style. The control sample was made from 100% semolina flour (SF), while three different samples were made by replacing 10, 20 and 30% SF with quinoa flour (QF) as follow:

Control: Pasta control prepared with 100% SF.

10% QFP: Pasta prepared with 90% SF and 10% QF.

20% QFP: Pasta prepared with 80% SF and 20% QF.

30% QFP: Pasta prepared with 70% SF and 30% QF.

The dry ingredients were combined into a homogenous mixture and poured onto a clean, smooth work area. Warm water at approximately 32-49° Celsius was slowly poured into a well formed in the center of the mounded flour. The water was incorporated by pulling flour from the inside wall using a fork. Once all the water was added and mixing with a fork became difficult, the remaining flour was blended in by hand. The crumbly dough mass was then kneaded for approximately 10 minutes, forming a smooth, elastic dough. Kneading was done by the repeated action of flattening the dough with the palm of the hand, rotating the dough, and folding over. The kneaded dough was wrapped in plastic film and set to rest at room temperature for one hour. Once rested, the dough ball was divided into two pieces for processing. Each dough piece was flattened and sent through the pasta machine (Imperia Tipo Lusso SP150, Torino, Italy) starting on the thickest setting (number 1). The dough was folded into thirds and sent through again. It was then folded in half, run through, and cut into manageable lengths. Sheets of dough were fed through the pasta machine at decreasing thicknesses (numbers 2, 3, and 4, respectively). The thin, flattened sheets were laid to dry for 10 minutes before being passed through the fettuccine cutter. The cut strands were laid on wire racks and covered with a towel to dry overnight. The dried pasta was stored in bags at room temperature until further use.

Analytical Methods:

Chemical composition: Moisture, ash, crude protein, fat and crude fiber contents were determined according to the methods outlined in **AOAC (2000).** Carbohydrates were calculated by difference as mentioned as follows: Carbohydrates = 100 – (% protein + % fat + % ash + % crude fiber).

Rheological properties: Rheological properties of dough were evaluated using Farinograph according to **AACC (2000).**

Color measurement: Objective evaluation of color of pasta samples was measured in the National Research Center, Giza, Egypt. Hunter L*(luminosity),a*(red intensity), and b*(yellow intensity).

Sensory evaluation: Sensory evaluation of cooked pasta was evaluated as described by **Hussein *et al*. (2006).**

Cooking quality of pasta: Cooking quality of pasta were carried out by measuring the increases in weight, volume and cooking loss after cooking according the methods of **AACC (2000).**

Texture profile analysis of Pasta: Hardness, Deformation at hardness, Peak Stress and Fracturability with 1% of load sensitivity analysis of uncooked and cooked pasta samples was conducted using The TVT Texture Analyzer (Perten instruments) according to TVT Method 10.0 following the method described by **Tang *et al*. (1999).** Data was obtained, calculated, and graphed using the texture analyzer PC software program Texture Expert Exceed (Version 2.62, Texture Technologies Corp., and Scarsdale, NY) to assess the effect of quinoa flour on textural attributes.

Statistical evaluation: The obtained results were evaluated statistically using analysis of variance as reported by **McClave & Benson (1991).**

RESULTS & DISCUSSION

Data in Table 1 show a comparison between Chemical composition contents of semolina flour (SF) and quinoa flour (QF). SF recorded 10.81 ±0.70, 13.10 ±0.50, 3.36 ±0.07, 5.43 ±0.01, 67.29 ±1.25 and 6.31 ±0.15% for moisture, crude protein, total fats, total ash, total carbohydrates and crude fiber, respectively. Meanwhile, QF recorded 10.78 ±0.07, 13.99 ±0.14, 3.87 ±0.01, 6.08 ±0.02, 65.44 ±0.39 and 7.14 ±0.08% for the same previous parameters, respectively. It could be observed from results that QF had the higher contents of protein, fat, ash and fiber as compared to those of SF. These results were with accordance with **USDA (2013)** which stated that quinoa flour contained (13.28 *g* moisture, 368 *kcal* energy, 14.12 *g* protein, 6.07 *g* total lipid, 2.38 *g* ash, 64.16 *g* carbohydrate, 7.0*g* fiber) *g per 100g*. While semolina flour contained (12.67 g moisture, 360 kcal energy, 12.68 g protein, 1.05 *g* fat, 0.77 *g* ash and 72.83 *g* carbohydrates) *g per 100g*.

Quinoa flour contained 11.2% moisture, 13.5% crude protein, 6.3% ether extract, 9.5% crude fibre, 1.2% total ash and 58.3% carbohydrate **(Ogungbenle, 2003).** The protein content of quinoa is higher than in cereals and ranges from14 to 18 % of the seed, as compared to maize (10%), rice (8%) and wheat (14%) (**Koziol, 1992**).

Farinograph parameters of four different pasta dough formulas (semolina flour, semolina flour with 10, 20 and 30% quinoa flour) were represented in Table 2. These pasta formulas regarding were evaluated for water absorption, arrival time, dough development time, dough stability, mixing tolerance index and dough weakening. Data show that fortification pasta dough with QF at 10, 20 and 30% caused a gradually increasing in mixing tolerance index and dough weakening comparing to pasta control. Meanwhile, the arrival time, dough development time and dough stability values were decreased gradually by the increasing of quinoa flour in pasta dough. 20 and 30% QF increased water absorption compared to control pasta.

Svec *et al*. (2011) investigated dough rheological properties and bread quality from wheat/quinoa composite flour made at rates from 0 to 30% supplements. Quinoa wholemeal incorporation in wheat flour did not influenced water absorption, but dough stability decreased dependently to basic flour quality and quinoa additions similarly to **Jancurová *et al*. (2009).** During dough kneading, up to 33% shorter development time and 50% dough stability with twofold breakdown were recorded for Q30. Contrary to that, **Jancurová *et al*. (2009)** described independence of development time on quinoa level and also dough stability prolongation.

Color characteristics were measured in pasta samples at four stages (the flour mixture before processing, pasta after processing before drying, dried pasta and pasta after cooking) and the obtained data were tabulated in Table 3.

Generally, the fortification of pasta with quinoa flour caused a significant decreasing ($p<0.05$) in brightness ($L*$ value) at all previous stages of pasta processing comparing with the control pasta which was significantly lighter than other samples. This decrease in brightness of pastas containing legume flours is in accordance with many researchers who have experimented with legumes such as chickpea, green pea, yellow pea, split pea, faba bean, soy, and lentil, as well as pseudo-cereals like quinoa (**Lorenz *et al*., 1993, Ugarcic-Hardi *et al*., 2003, Zhao *et al*., 2005, Wood 2009, Petitot *et al*., 2010b). Ugarcic-Hardi *et al.* (2003**) attributed the decrease in brightness to a higher ash content in legume flours.It is known that consumers prefer bright yellow translucent pasta products, but the limit of acceptable brightness is undefined.

Similar to lightness decreasing, redness increased ($a*$ value increased) as more quinoa flour was added. It can be concluded that the amount of quinoa flour added to pasta significantly affects redness of the product. The control pasta was found to be the most yellow (highest *b** value), with yellowness significantly ($p<0.05$) decreasing as more quinoa flour was added. This is in accordance with other researchers who have seen a decrease in yellowness of pastas containing chickpea, green pea, yellow pea, lentil, and quinoa flours (**Lorenz *et al*., 1993, Zhao *et al*., 2005, Wood 2009**). This decrease in yellowness may be due to the leaching and/or degradation of color pigments, such as carotenoids and xanthophyll (**Wood, 2009**).

Similar results were found by **Petitot *et al*., (2010b)** where pasta fortified with faba bean flour saw a significant increase in redness. **Petitot *et al*., (2010b)** also noted that yellowness (*b** values) was not affected in this change. This is important to note because according to **Ugarcic-Hardi *et al*., (2003),** bright yellow pasta is achieved by having both high *b** values and low *a** values.

The effect of quinoa flour (QF) fortification of pasta weight increase, volume increase and cooking loss percentage were studied and the obtained data was tabulated in Table 4. A significant increase ($p<0.05$) were observed in weight and volume increase values gradually by increasing QF percentage in pasta. Weight increase percentage recorded 235±3.00, 255±4.32 and 275±5.33% for pasta with 10, 20 and 30% QF, respectively. On the other hand, while volume increase percentage recorded 180±3.20, 195±5.60 and 210±3.55 for pasta with 10, 20 and 30% QF, respectively, meanwhile control pasta made with 100% SF recorded 220±2.80 and 165±4.42 for weight and volume increase percentage, respectively. Cooking loss was significantly ($p<0.05$) affected by the addition of QF. The control pasta made with 100% SF recorded significant ($p<0.05$) less cooking loss (3.5±0.14) comparing with pasta containing QF. It could be noticed that the cooking loss values increase gradually by the increasing of QF percentage as recorded 5.00±0.21, 6.5±0.28 and 7.5±0.42 for pasta samples with 10, 20 and 30% QF. This is in accordance with **Bahnassey and Khan (1986)** and **Lorenz et al. (1993),** who found that cooking loss increased as the level of fortification increased. Fortifying pasta with legume flours (pea, lupin, chickpea, lentil, split pea, or faba bean) increases cooking loss (**Nielson *et al.*, 1980, Rayas-Duarte *et al.*, 1996, Zhao *et al.*, 2005 and Petitot *et al.*, 2010b).** Also, **Lorenz et al. (1993)** also found that adding quinoa flour to pasta resulted in a higher cooking loss than the control made from wheat flour. **Duszkiewicz *et al*. (1988)** observed higher water absorption and cooking loss in spaghetti blended with legume flour and concentrates. Legume supplementation of pasta resulted in greater cooking loss when compared to control **(Bahnassey and Khan, 1986)**

The addition of quinoa flour was significantly ($p<0.05$) affected consumer acceptance of the pasta products. The average scores given by panelists in color, flavor, mouthfeel, elasticity and overall acceptability can be seen in Table 5. The control pasta was significantly ($p<0.05$) more liked than pastas containing quinoa flour. The least favored pasta was 30 % quinoa flour pasta. This may be due to the poor textural properties of the samples. Of the fortified pastas, 10% quinoa flour pasta was found to be the most favored.

These results are in accordance with other researchers who found that pasta made from 100% semolina flour received the highest overall acceptability when compared to pastas supplemented with legume and pseudo-cereal flours **(Bahnassey and Khan 1986, Zhao *et al*., 2005; Mastromatteo *et al*., 2011).** Quinoa has been incorporated into wheat noodles **(Lorenz *et al*., 1993).** No statistically significant difference was found between noodles made with 10% and 30% quinoa. Noodles with 50% quinoa content were ranked least acceptable. Quinoa flour was extruded with corn grits to produce expanded snack products. Addition of quinoa produced a darker, less yellow extruded product. The products were rated as moderately acceptable (**Coulter & Lorenz, 1991a, 1991b; Lorenz *et al*., 1995).**

Texture profile of dried and cooked pasta was represented in Table 6. Hardness of the pastas was affected by the fortification of pasta with quinoa flour. Hardness is the height of the force peak of the first compression cycle **(Bourne 2002)**. In this study, it is the maximum force required to compress the dried pasta samples recorded 17.55, 32.30, 34.32 and 48.32N for control sample, 10, 20 and 30% quinoa flour pasta, respectively. Meanwhile, the maximum force required to compress the cooked pasta samples recorded 3.02, 3.47, 3.86 and 4.09 for control sample, 10, 20 and 30% quinoa flour pasta, respectively.

The control pasta (dried or cooked) was found to be less hard than the fortified pasta products. Pasta formula fortified with 30% quinoa flour was harder than pastas with 10 and 20% quinoa flours. The addition of quinoa flour has a greater effect on cooked and dried pasta hardness. These results are similar to those found by **Petitot *et al*., (2010b)** where pasta fortified with 35%

legume flours (split pea or faba bean) significantly increased the hardness of pasta, which they attributed to increased protein content and decreased water uptake. **In 1993, Lorenz *et al*.** experimented with adding 10, 30, and 50% quinoa flour to wheat pasta. The addition of quinoa required more water for mixing, made the pasta darker in color, and increased cooking loss. Pasta made with 50% quinoa flour was shown to be poor in flavor and texture and was deemed unacceptable (**Lorenz *et al*.**, **1993**).

Data in Table 7 show the effect of substitution of 10, 20 and 30% of semolina flour (SF) by quinoa flour (QF) on the chemical composition of processed pasta comparing with the control sample. Results show that the fortification pasta with QF increased significantly ($p<0.05$) the protein, fat, ash and fiber contents of pasta comparing with control pasta sample. On the other hand, the addition of QF caused a significant decreasing ($p<0.05$) in moisture and carbohydrates contents of processed pasta. These results due to the higher contents of protein, fat and ash of quinoa flour comparing with semolina flour. In quinoa flour pasta (QFP), protein contents recorded 10.07±0.07, 11.19±0.22 and 12.36±0.01%, while fat contents recorded 1.71±0.07, 2.23±0.07 and 2.80±0.10% for 10, 20 and 30% QFP, respectively comparing with semolina flour pasta which recorded 9.13±0.07 and1.19±0.03% for protein and fat, respectively.

It could be noticed that the pasta sample with 30% QF caused an obvious increasing in protein, ash, fat and fiber contents comparing with other pasta samples. The results agreed with other research workers, **Gurpreet *et al*. (2011); Young-Soo-Kim (1998); Osorio *et al.* (2008); Bahnassey and**

Khan (1986) who reported the incorporation of plant proteins flour increased the protein, fibre and ash contents of the final products.

CONCLUSION

The pasta product with the most beneficial ratio of quinoa flour is that containing 30% quinoa flour. It had the highest protein, fat, ash and fiber contents. Pasta samples cooking loss was found to be in an acceptable range, and besides the texture attributes were not adversely affected by fortification. The color characteristics of pasta 10% QF were also nearly to that of the control, leading to a high level of visual acceptability.

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Table (1): Chemical composition of raw materials:

Samples	Parameters					
	Moisture %	**Protein %**	**T. fat %**	**T. ash %**	**Carbohydrates %**	**Fiber %**
Semolina flour	10.81± 0.70	13.10± 0.50	3.36± 0.07	5.43± 0.01	67.29± 1.25	6.31± 0.15
Quinoa flour	10.78± 0.07	13.99± 0.14	3.87± 0.01	6.08± 0.02	65.44± 0.39	7.14± 0.08

Table (2): Effect of quinoa flour fortification on farinograph parameters of pasta dough

Samples	Water absorption (%)	Arrival time (min)	Dough development time (min)	Dough stability (min)	Mixing tolerance index (BU)	Dough weakening (BU)
Control	57.5	7.0	11.0	11	20	**60**
10% QFP	57.5	4.5	8.0	10.0	25	**70**
20% QFP	60.5	5.5	7.5	9.0	35	**80**
30% QFP	**62.5**	**5.0**	**7.0**	**7.5**	**60**	**100**

QFP: Quinoa flour pasta

Table (3): Effect of quinoa flour fortification on color characteristics of pasta

Color parameters of Flour mixture			
Samples	**L***	**a***	**b***
Control	85.40±0.21a	2.25±0.03a	20.85±0.10a
10% quinoa flour pasta	83.81±0.11b	1.95±0.05b	19.15±0.07b
20% quinoa flour pasta	82.47±0.07b	1.70±0.03c	17.88±0.09c
30% quinoa flour pasta	81.55±0.04c	1.41±0.04d	16.80±0.09d
LSD at 0.05	2.150	0.244	0.522
Color parameters of Processed pasta before drying			
Samples	**L***	**a***	**b***
Control	77.61±0.28a	1.89±0.035c	20.05±0.05b
10% QFP	73.22±0.45b	1.80±0.02c	19.26±0.02c
20% QFP	62.49±0.09c	2.43±0.06b	20.83±0.07a
30% QFP	62.02±0.07c	2.57±0.07a	21.35±0.07a
LSD at 0.05	0.775	0.274	0.547
Color parameters of Processed pasta after drying			
Samples	**L***	**a***	**b***
Control	77.01±0.381a	2.16±0.07c	19.55±0.14c
10% QFP	70.11±0.139b	3.07±0.120b	22.97±0.56b
20% QFP	66.15±0.302c	3.42±0.124a	23.57±0.03b
30% QFP	63.55±1.53d	3.45±0.07a	24.09±0.07a
LSD at 0.05	2.071	0.290	1.107
Color parameters of Cooked pasta			
Samples	**L***	**a***	**b***
Control	71.17±0.55a	0.66±0.01d	17.19±0.07c
10% QFP	62.17±0.23b	1.62±0.02c	18.40±0.07a
20% QFP	59.38±0.35c	2.31±0.02b	17.66±0.05b
30% QFP	53.67±0.32d	2.53±0.04a	17.16±0.07c
LSD at 0.05	2.574	0.192	0.421

QFP: Quinoa flour pasta, L: luminosity, a*: red intensity, and b*: yellow intensity*

Table (4): Effect of quinoa flour fortification on cooking quality of pasta

Samples	Weight increase (%)	Volume increase (%)	Cooking loss (%)
Control	220±2.82d	165±4.42d	3.5±0.14d
10% QFP	235±3.00c	180±3.20c	5.00±0.21c
20% QFP	255±4.32b	195±5.60b	6.5±0.28b
30% QFP	275±5.33a	210±3.55a	7.5±0.42a
LSD at 0.05	12.801	12.453	0.791

QFP: Quinoa flour pasta

Table (5): Effect of quinoa flour fortification on organolyptic characteristics of pasta

Samples	Color (10)	Flavor (10)	Mouthfeel (10)	Elasticity (10)	Overall acceptability (10)	Total (50)
Control	9.75 ± 0.35 a	9.83 ± 0.28 a	9.70 ± 0.23 a	9.81 ± 0.25 a	9.55 ± 0.52 a	47.81 ± 1.02 a
10% QFP	8.9 ± 0.42a	9.33 ± 0.57a	9.01± 0.42a	8.50 ± 0.35b	8.95± 0.46 [a]	44.18 ± 1.25b
20% QFP	7.65 ±0.35b	9.11 ±0.28a	8.10 ± 0.35b	7.13 ± 0.41c	7.13 ± 0.37b	42.25± 0.88c
30% QFP	7.20 ±1.41b	8.26 ±0.64b	6.70± 0.32c	6.50 ± 0.62d	6.04 ± 0.35c	38.66 ±1.52d
LSD at 0.05	0.9311	0.8996	0.9211	0.9621	0.8621	2.207

QFP: Quinoa flour pasta

Table (6): Effect of quinoa flour fortification on texture profile of dried and cooked pasta

Samples	**Hardness (N)**	**Deformation at hardness (mm)**	**Hardness work (mJ)**	**Peak Stress Dyn/cm^2**	**Fracturability with 1% of load sensetivity (N)**
Dried pasta					
Control	17.55	0.23	0.80	55904152	17.55
10% QFP	32.30	2.15	3.20	102876128	1.93
20% QFP	34.32	1.87	4.70	109309792	1.13
30% QFP	48.32	0.49	3.00	153876960	48.32
Cooked pasta					
Control	3.02	1.61	3.40	9619262	3.02
10% QFP	3.47	1.62	1.10	11055905	3.47
20% QFP	3.86	1.98	1.30	12305160	0.07
30% QFP	4.09	1.73	1.30	13023481	4.09

QFP: Quinoa flour pasta *Hardness = The maximum force of the 1st compression*

Table (7): Effect of quinoa flour fortification on chemical composition of pasta

Samples	Moisture %	C. protein %	T.fat %	T.ash %	T. carbohydrates %	C. fiber %
Control	12.81± 0.19a	9.13± 0.07d	1.19± 0.03d	2.97± 0.12d	73.88± 0.35a	2.04± 0.01d
10% QFP	12.43± 0.03b	10.07± 0.07c	1.71± 0.07c	3.54± 0.09c	72.23± 0.29b	3.10± 0.02c
20% QFP	12.06± 0.3c	11.19± 0.22b	2.23± 0.07b	4.13± 0.01b	70.36± 0.33c	4.17± 0.07b
30% QFP	11.47± 0.02d	12.36± 0.01a	2.80± 0.10a	4.78± 0.05a	68.57± 0.14d	5.27± 0.08a

QFP: Quinoa flour pasta

Evaluation of quinoa (*Chenopodium quinoa Willd*.) flour fortification on the quality of pasta production

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تقييم أثر التدعيم بدقيق الكينوا على خواص جودة إنتاج المكرونة

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الملخص العربي

استهدفت الدراسة تقييم أثر التدعيم بنسب مختلفه من دقيق الكينوا على جودة إنتاج المكرونه حيث تم تدعيم المكرونة بنسبة 10 و 20 و 30٪ من دقيق الكينوا، ثم مقارنتها من حيث خواص الفارينوغراف، وخصائص اللون، وجودة الطهي، وقبول المستهلك، والملمس والتركيب الكيميائي بالكنترول (100٪ مكرونه مصنعه من دقيق السميد) أدى تدعيم دقيق المكرونه بدقيق الكينوا إلى ارتفاع تدريجي في نسبة امتصاص العجينه للماء وضعف العجينه، في الوقت الذي أدت فيه إضافة دقيق الكينوا إلى إنخفاض تدريجي في زمن الوصول وثبات العجين مقارنة بالكنترول كما أدى تدعيم المكرونه إلى زيادة قتامة لونها عند مقارنتها بمكرونة السميد (الكنترول) تدريجيا بارتفاع نسبة التدعيم. وبدراسة أثر إضافة دقيق الكينوا على جودة الطهي، تم ملاحظة زيادة الوزن والحجم مع ارتفاع نسبة الفقد في الطهي كلما ارتفعت نسبة التدعيم مقارنة بالكنترول ولكن كان هذا الفقد في الحدود المسموحه. كما تمتعت جميع عينات المكرونه المدعمه بدقيق الكينوا بالقبول العام لدى الأشخاص القائمين بالاختبار الحسي. كما لوحظ ارتفاع نسبة الصلابه وارتفاع محتوى البروتين والدهون والرماد والألياف تدريجيا بارتفاع نسبة التدعيم مقارنة بالكنترول. و توصي الدراسه بضرورة انتاج مكرونه مرتفعة القيمه الغذائيه ومرتفعه في نسبة البروتين وذلك عن طريق تدعيمها بنسب مختلفه من دقيق الكينوا.

الكلمات المفتاحية: *المكرونه – الكينوا – الفارينوجراف – جودة الطهي – الصلابه.*