World Journal of Dairy & Food Sciences 19 (1): 01-09, 2024
ISSN 1817-308X

DOI: 10.5829/idosi.wjdfs.2024.01.09

Utilization of Quinoa Flour in Meat Burger Preparation

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Abstract: The objective of this work was to assess the effects of quinoa flour (QF) in the improving the quality characteristics and physo-chemical properties of beef burger. The effects of quinoa flour addition (5, 10 and 15 %) on chemical composition, pH, quality attributes, cooking parameters, texture characteristics and sensory evaluation of beef burgers were evaluated. Furthermore, amino acids profile of quinoa flour, beef meat and beef burger samples were determined. Ash and total carbohydrate contents of burger samples increased while protein and fat content decreased by the addition of quinoa. The control sample had the lowest pH than other treatments. The results indicated that addition of quinoa significantly decreased Thiobarbituric acid value (TBA) and Total volatile nitrogen (TVN) content for burger samples compared to control sample. The cooking yield and reduction in diameter and thickness of burgers were improved. Texture analysis showed that with the addition of quinoa, hardness, adhesiveness, chewiness, Springiness, Cohesiveness and resilience index values decreased. The sample containing 15 % of QF was the lowest acceptable sample. Addition of QF in beef burger samples leads to an increase in the content of total non-essential amino acids, especially in samples prepared with 15% QF. Meanwhile, the total essential amino acid content decreased.

Keywords: Beef burger · Quinoa · Amino acid · Quality attributes · Cooking parameters · Texture characteristics.

INTRODUCTION

Consumers often avoid consuming meat and meat products due to health concerns caused by animal fat, saturated fatty acids, cholesterol, sodium nitrite and sodium chloride in meat products [1]. However, food and nutritional scientists and some leading health organizations have also suggested that decreasing harmful components in meat products to human health and food and nutritional scientists and some leading health organizations have also suggested that decreasing harmful components in meat products to human health and improved meat products compositions with incorporated health enhancing ingredients [2]. Enrichment of meat products with some vegetable source compounds such as some cereals and legumes have been considered as a good strategy to development of functional meat products and studied extensively in recent years. The quinoa, which is shown as one of the most valuable sources, has also begun to be tried in the formulations of different products in many studies and their results have shown that quinoa can be very important ingredient for improving food quality and nutritional value [3].

Quinoa (*Chenopodium quinoa* Willd.) is a seed crop, which has some healthy properties such as easy to digest and a good sources of protein, dietary fiber, minerals and essential amino acids e.g. lysine, methionine and histidine [4]. Additionally, the quinoa seed contains antioxidant compounds such as carotenoids and flavonoids [5]. Quinoa was found to be a good source of minerals where it contains more calcium, magnesium, iron, and zinc than common cereals and its seed lipids appear to be a high quality edible vegetable oil, similar in the fatty-acid composition to soybean oil [6].

The United Nations today highlighted the quinoa, known as an Andean "super food", and other underused crops in the fight against hunger. The United Nations General Assembly has therefore declared 2013 as the

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"International Year of Quinoa", in recognition of ancestral practices of the Andean people, who have managed to preserve quinoa in its natural state as food for present and future generations, through ancestral practices of living in harmony with nature [7].

With the growing interest in quinoa's nutritional and medicinal value, methods for producing, concentrating, and utilizing several value-added products from quinoa have been developed over the past 25 years [8]. The main objective of this research was studying the possibility of using different concentrations of quinoa flour as a partial meat substitute and studying the impact of that on the chemical, nutritional and sensory characteristics of beef burger.

MATERIALS AND METHODS

Materials: Quinoa seeds (*Chenopodium quinoa* Willd) were obtained from Food Technology Research Institute, Agriculture Research Center, Giza, Egypt. Frozen beef meat (imported from Brazil), stored at - 18°C was obtained from a supermarket at Cairo city, Egypt, fresh beef fat (Tallow) was obtained from butcher shop, at Cairo city, Egypt and immediately transported in ice box to the laboratory. Spices (black pepper, cubeb, dried onion, dried garlic, sodium chloride, cumin, nutmeg, cloves, ginger, cinnamon and coriander), salt and soya flour were obtained from a supermarket at Cairo city, Egypt. Ascorbic acid and sodium pyrophosphate were obtained from El-Nasr Co., Cairo, Egypt.

Preparation of Quinoa Flour (QF): Quinoa seeds were cleaned and freed of broken seeds, dust and other foreign materials. Whole seeds were washed with cold water 4 -5 times or until there was no foam to remove saponins, then oven-dried at 45±1°C for 24 h or until being dry. The whole quinoa seeds were ground into flour using stainless steel electric grinder using a laboratorial disc mill and sifted through a 60 mesh, then packed in polyethylene bags and stored at 4 ± 1°C until used [9].

Preparation of Beef Burger: The lean meat and fat were separately ground in a meat grinder. Four treatments were formulated according to (Table 1). The control and burgers were formulated to contain 71% beef meat and 10% fat tissues. Different levels of quinoa flour (5 %, 10 % and 15%) were used to replace equal amounts of added beef meat. The quinoa flour was added after rehydrated with water (at a ratio of 1:1 w/ v). Appropriate amounts of each formulation were mixed by hand, subjected to final grinding (0.5 cm plate) and processed into burgers (60 g weight and 10 cm diameter). Burgers were placed on plastic foam trays, wrapped with polyethylene film and kept frozen at -18°C until further analysis.

Table 1: Formulas of beef burger contained different level of quinoa flour.

Ingredients (%)	Control	Substitution levels from quinoa flour 5%	10%	15%
Beef meat	71	66	61	56
Fat tissues	10	10	10	10
Quinoa flour	---	5	10	15
Soya flour	10	10	10	10
Sodium chloride	1.5	1.5	1.5	1.5
Spices mixture	2	2	2	2
Minced garlic	1	1	1	1
Chopped onion	3.5	3.5	3.5	3.5
Cumin powder	1	1	1	1
Sodium pyrophosphate	0.3	0.3	0.3	0.3
Total	100	100	100	100

Analytical Methods:

Chemical Analysis: Moisture, crude protein, ash and crude fat contents were determined according to Official Methods [10]. Carbohydrates were calculated by difference according to Turhan *et al*. [11] as follows:

$$\% \text{ carbohydrate} = 100 - (\% \text{ moisture} + \% \text{ protein} + \% \text{ ash} + \% \text{ fat})$$

Determination of Amino Acids: Amino acids profile of quinoa flour, beef meat and beef burger samples were determined according the method described in A.O.A.C. [10] using Biochrom 20 automatic high performance amino acid analyzer.

pH Value: pH values of studied beef burger samples were measured in a homogenate prepared with 10g sample and distilled water (100 ml), using ICM 41150 pH meter [11].

Thiobarbituric Acid Value (TBA): Thiobarbituric acid (TBA) was determined according to the method of Lemon [12].

Total volatile nitrogen (T.V.N): Total volatile nitrogen was determined according to the method described by Malle and Tao [13].

Physical Properties:

Cooking Loss: Cooking loss was determined according to Lee *et al*. [14]. It was measured after grilling samples. Cooking loss was calculated as follows:

$$\% \text{ cooking loss} = \frac{\text{Raw sample weight - Cooked sample weight}}{\text{Raw sample weight}} \times 100$$

Cooking yield: Cooking yield was calculated as given by El- Nemer [15].

% Cooking yield = 100 - % Cooking loss

Shrinkage: The shrinkage percentage was calculated as described by George and Berry [16] using the following equation: % Shrinkage = (Uncooked diameter or length (cm) - Cooked diameter or length (cm) ×100) / Uncooked diameter or length (cm).

Texture Profile Analysis: Texture profile analysis (TPA) test was performed on cooked samples using a texture profile analyzer (Brookfield, CT3, Middleboro, MA, United States) to determine hardness, adhesiveness, chewiness, springiness, cohesiveness, and resilience. Samples were cut into (1 × 1 × 1 cm) from cooked burger and then held for equilibration to room temperature (20°C), wrapped with plastic film for TPA. Test conditions were (aluminum rectangular probe; 5 cm × 4 cm); test speed 5 mm/s; pre-test speed 2 mm/s, post-test speed 2 mm/s; compression 70% and 50 kg load cell as described by Bourne [17].

Sensory Evaluations: Sensory evaluation of samples were put in a tray then grilled using hotplate (Mienta HP41325A Duetto Hotplate, China- at 120°C for 2-3 min) until the color turn to golden yellow, then evaluated organoleptically. Cooked samples were evaluated by 10 staff members in the meat and fish Technology Research Department, Food Technology Research Institute Agriculture Research center, and who are familiar with these products. A 9 point hedonic scale (where 1 corresponding to dislike extremely to 9 represents highly liked) were used to evaluate the sensory attributes of color, taste, odor, texture, appearance and overall acceptability of the prepared samples according to Gelman and Benjamin [18].

Statistical Analysis: The obtained results were subjected to statistical analysis according using SPSS [19]. Significant differences among individual means analyzed by Duncan multiple range tests [20].

RESULTS AND DISCUSSION

The Proximate Chemical Composition of Quinoa Flour and Beef Meat: Table 2 showed the results of the chemical composition analysis of quinoa flours and beef meat imported. Regarding the approximate chemical composition of quinoa flour, the results obtained showed 11.28% moisture, 15.10% crude protein, 6.37% crude fat, 2.40% ash and 64.85% carbohydrates. In this direction, Moawad [21] showed that whole quinoa flour contains 11.36% moisture, 15.10% crude protein, 6.33 fats, 3.80% crude fiber and 3.72% ash. Also, beef recorded moisture content of 72.35%, crude protein 16.21%, crude fat 8.62%, ash 0.98%, carbohydrates 1.84%. Mousa [22] explained that imported frozen beef contains moisture, protein, fat, ash and carbohydrate values of 74.84, 21.46, 2.28, 0.98 and 0.44%, respectively.

Chemical Composition of Beef Burger Samples Formulated with Different Levels of Quinoa Flour (QF): Table 3 showed the chemical composition of beef burger substitution with different ratio of quinoa flour. It can be seen that the moisture content of the beef burger

Table 2: Chemical composition of quinoa flour (QF) and beef meat.

	Chemical composition (%)				
Raw materials	Moisture	Crude protein	Crude fat	Ash	Total carbohydrate
Quinoa flour	11.28^{b}±0.28	15.10^{b}±0.12	6.37^{b}±0.08	2.40^{a}±0.05	64.85^{a}±0.16
Beef meat	72.35^{a}±0.45	16.21^{a}±0.20	8.62^{a}±0.32	0.98^{b}±0.14	1.84^{b}±0.25

Table 3: Chemical composition of beef burger samples formulated with different levels of quinoa flour (QF).

		Chemical composition (%)				
Raw materials		Moisture	Crude protein	Crude fat	Ash	Total carbohydrate
Control sample		58.40^{a}±0.04	21.57^{a}±0.01	15.06^{a}±0.02	2.28^{b}±0.02	2.69^{b}±0.02
Substitution levels	5%	57.86^{a}±0.11	21.34^{a}±±0.0	15.00^{a}±±0.01	2.65^{b}±0.01	3.15^{ab}±0.04
from quinoa flour	10%	57.23^{ab}±0.02	21.15^{ab}±0.02	14.87^{b}±0.01	3.04^{ab}±0.02	3.71^{a}±0.18
	15%	56.79^{b}±0.03	20.78^{b}±0.01	14.69^{b}±0.02	3.32^{a}±0.00	4.42^{a}±0.01

*Means at the same column followed by different letters are significantly different at (P≤0.05)

Table 4: Amino acid composition of raw materials and beef burger samples formulated with different levels of quinoa flour (g AA/ 100g of protein).

Amino acids	Quinoa flour	Beef meat	Control	Substitution levels with quinoa flour 5%	10%	15%
Essential Amino Acids						
Hisitidine	3.18	2.90	2.72	2.79	2.83	2.88
Isoleucine	3.91	5.10	5.07	4.98	4.86	4.72
Leucine	6.42	8.40	7.64	7.49	7.41	7.39
Lysine	5.17	8.67	8.43	8.41	8.37	8.06
Methionine	2.32	3.30	2.70	2.56	2.38	2.27
Phenylalanine	4.24	6.13	6.02	6.00	5.94	5.00
Therionine	3.43	4.00	3.51	3.38	3.36	3.15
Valine	4.50	6.18	5.78	5.72	5.70	5.66
Tyrosine	3.20	3.73	3.51	3.45	3.38	3.33
Cystine	1.72	1.40	1.37	1.50	1.55	1.59
Total Essential Amino Acids	38.09	49.81	46.75	46.28	45.78	44.05
None-Essential Amino Acids						
Aspartic acid	7.89	8.80	8.57	8.34	8.24	8.00
Serine	4.11	6.87	6.80	5.71	5.67	5.49
Proline	3.71	2.40	2.22	2.33	2.41	2.52
Glutamic acid	15.63	14.40	13.82	14.38	14.90	15.12
Glycine	5.30	7.08	7.01	6.88	6.27	6.10
Alanine	8.40	4.97	4.90	7.03	7.22	7.35
Arginine	9.07	6.60	5.66	7.40	7.52	8.63
Total Non-Essential Amino Acids	54.11	51.12	48.98	52.07	52.23	53.21

decreased as the percentage of quinoa flour increased with non-significant difference. The moisture content decreased from 58.40% in the control sample to 56.79% for the sample containing 15% QF. It was found that our results were at the same direction as those obtained by Shokry [23], which showed that the moisture content of raw beef burgers decreased in all treated samples compared to the control. Also, showed that adding quinoa led to a decrease in moisture content in all samples and this effect could be a result of the increase in solid content in the products. Al-Juhaimi *et al*. [24] who used moringa seeds flour as a binder in beef burgers. Serdaroglu [25] reported a decrease in moisture content in oatmeal beef patties due to increased solid contents. Moreover, Alakali *et al*. [26] reported that an increase in the proportion of Bambara groundnut seed flour reduced the moisture content of beef patties.

The percentage of crude protein in the burger samples has the same trend as the moisture content in the burger samples. Crude protein decreased with a significant difference from 21.57 to 20.78% by increasing the QF substitution ratio from control (without QF) to 15%. This decrease in protein content may be due to hydrolysis of protein by natural meat enzymes and bacterial enzymes that are produced as well as loss of water-soluble protein by separate drip [27]. In contrast, crude fat decreased from 15.06 to 14.69%, with a significant difference when the percentage of QF substitute increased from 0 (control) to 15%. It can be noted that QF has a lower crude fat content than meat (6.37 and 8.62%, respectively). Ash and carbohydrate contents increased with increasing QF ratios in all burger formulations with a significant difference.

Amino Acids Composition of Beef Burger Formulated with Different Levels Quinoa Flour: From the results in Table 4, it can be noticed that an increase in the percentage of QF in beef burger samples leads to an increase in the content of total non-essential amino acids, especially in samples prepared with 15% QF, which recorded 53.21%. Meanwhile, the total essential amino acid content decreased in beef burger samples prepared with QF. The composition of samples containing 5% QF obtained the highest percentage of total essential amino acids, which recorded 46.28% among the samples to which quinoa was added. It can also be noted that all burger samples containing QF were rich in essential amino acids such as leucine, Lysine, phenylalanine and valine but less than the control sample. Therefore, fortified meat products such as quinoa flour samples can represent a healthy alternative for people and can complement protein sources that are low in essential amino acids. Shokry [23] explained that the percentage of protein in quinoa flour represents 14-20%, and it contains a good balance between the amino acids that make up the protein as it is particularly rich in essential amino acids

Table 5: Quality attributes of different beef burger samples.

	Control sample	Substitution levels from quinoa flour 5%	10%	15%
pH	6.18^{a}±0.00	6.10^{ab}±0.00	6.02^{ab}±0.01	5.98^{b}±0.00
TBA (mg/kg)	0.19^{a}±0.01	0.17^{a}±0.00	0.14^{ab}±0.01	0.12^{b}±0.00
TVN (mg/ 100g)	8.86^{a}±0.02	8.53^{a}±0.10	7.91^{ab}±0.06	7.37^{b}±0.04

Table 6: Physical properties of different beef burger samples.

	Control	Substitution levels from quinoa flour 5%	10%	15%
Cooking yield	79.59^{b}±0.63	83.78^{ab}±0.45	85.42^{ab}±0.12	87.50^{a}±0.27
Cooking loss	20.41^{a}±0.40	16.22^{ab}±0.45	14.58^{b}±0.20	12.50^{b}±0.30
Shrinkage	22.00^{a}±0.47	20.29^{ab}±0.21	18.75^{b}±0.66	17.91^{b}±0.63

*Means in the same raw followed by different letters are significantly different at ($P \leq 0.05$)

such as lysine and methionine and thus provides protein with high biological value. Therefore, quinoa is one of the few plants that provide all the essential amino acids necessary for human life and unlike grain proteins that are poor in lysine in particular, quinoa proteins are accepted as high-quality proteins [28].

Quality Attributes of Beef Burger Formulated with Different Levels of Quinoa Flour: The pH value is an important property because of its influence on shelf life, color, water-holding capacity, and texture of meat and meat products [29]. Table 5 showed that the pH value decreased due to the addition of quinoa with a significant difference. The pH value of the control sample was 6.18 and lowered to 6.10, 6.02 and 5.98 in beef burgers containing 5, 10 and 15% QF, respectively. These results are consistent with Dzudie *et al*. [30] who reported that plant-derived components, which had acidic pH, when incorporated in meat products reduced pH of products as the level of incorporation increased.

The same table also cleared that the value of TBA decreased by increasing the QF ratios. Moreover, it could be noticed the significant differences between control and sample containing 15% QF. Also, the value of TBA in the control sample was 0.19 mg/kg and decreased to 0.17, 0.14 and 0.12 mg/kg in samples containing 5, 10 and 15% QF, respectively. Previous studies have reported that quinoa has significantly higher antioxidant activity than some grains due to its phenolics and flavonoids content and can be used as a source of free radical scavenging agents [31, 32].

Regarding the TVN content in beef burger containing QF, it decreased obviously with a significant difference between control and sample containing 15% QF by increasing of QF levels. Decomposition of beef burger protein leads to the formation of some basic compounds such as volatile nitrogen compounds, amines, and hydrogen sulfide, which in turn increases the pH value [33].

Physical Properties of Beef Burger Formulated with Different Levels of Quinoa Flour: Cooking properties such as cooking yield, cooking loss and shrinkage are some of the most important factors for the meat industry in order to predict the behavior of products during cooking. Table 6 showed the effect of QF on cooking yield, cooking loss and shrinkage of beef burgers. It can be seen that all burger samples containing QF had higher cooking yield and lower cooking loss compared to the control sample. The control sample had the highest cooking loss value (20.41%) and the lowest cooking yield value (79.59%) among the other samples studied.

There was a significant increase in cooking yield from 79.59% for the control formulation to 83.78, 85.42 and 87.50% for QF 5, 10 and 15%, respectively. Similar results were obtained by Baioumy *et al*. [28], who reported that increasing the concentration of added quinoa seeds led to a decrease in the percentage of cooking losses in beef burgers and an increase in the percentage of cooking productivity. These results confirmed that adding quinoa improves the quality characteristics of beef burgers. However, Yogesh *et al*. [34] found that cooking loss was significantly reduced in a meat mixture treated with flaxseed powder as compared to a control sample, due to the ability of flaxseed to retain moisture in the matrix. Similar results were obtained with Alakali *et al*. [26] reported on the cooking yield of beef patties prepared from Bambara groundnut seed flour, who demonstrated an increase in cooking yield with increasing level of mustard flour incorporated into beef patties. However, adding quinoa flour to beef burgers significantly improved the diameter, thickness, and shrinkage of the samples ($P<0.05$).

The addition of quinoa flour decreased the percentage of cooking losses and increased the percentage of cooking yield with a significant difference. These results confirmed that the addition of quinoa improves the quality characteristics of beef burgers. For shrinkage, the lowest values of shrinkage, decrease in diameter and thickness were observed in the burger samples containing 15% quinoa flour ($P<0.05$). This improvement in cooking parameters can be linked to the functional properties of quinoa flour. Several studies have reported that quinoa flour has high water and oil holding

Table 7: Texture profile analysis of different beef burger samples.

TPA	Control sample	Substitution levels from quinoa flour 5%	10%	15%
Hardness (N)	18.64	17.28	16.72	15.35
Adhesivenenss (mj)	6.77	5.84	4.43	3.60
Chewiness	9.62	8.48	7.25	6.76
Springiness	0.80	0.75	0.68	0.53
Cohesiveness	0.77	0.61	0.52	0.48
Resilience	0.58	0.46	0.33	0.29

capacity, emulsification and foaming ability, and gelation properties [35, 32, 36, 37]. The dietary fiber, starch and protein in quinoa flour increased cooking productivity and reduced shrinkage of burger samples. These results are consistent with studies on meat products containing dietary fiber, some plant proteins, and bakery products containing quinoa flour [38, 39 and 40].

Texture Profile Analysis of Beef Burger Formulated with Different Levels of Quinoa Flour: Texture profile analysis (TPA) parameters better reflect the contribution of proteins to textural properties than the contribution of starch to texture [41]. Hardness, adhesiveness, chewiness, springiness, cohesiveness and resilience were investigating the effect of quinoa flour substitution at different levels (5, 10 and 15%) on the texture profile analysis of beef burger.

From the obtained data (Table 8), beef burger samples containing 15% quinoa flour had the lowest hardness, adhesiveness, chewiness, springiness, cohesiveness and resilience index values. Meanwhile, samples containing the 5% quinoa flour had the highest values for these properties ($P<0.05$). Responsible for these results may be hydro-chemical and physical properties of components in quinoa flour. Some researchers reported that carbohydrates such as starch and dietary fiber component in the added vegetable sources may interact with water and fat of meat products to form a softer texture thus leading to a change in textural properties [38, 42]. Adhesiveness is the negative force area of the first bite, or the work necessary to pull the molars away from the food [43]. From the obtained results, the control sample had greater adhesiveness than those containing quinoa flours. Cohesiveness is defined as the degree to which the sample can be deformed before it breaks [9]. From this table it could be noticed that, when the quinoa flour level was increased, the cohesiveness values were decreased.

Quinoa flour level had a clear effect on springiness of burger. Springiness can be defined as the rate at which the deformed beef meatball springs back after the compression [44]. From the obtained data, it could be observed that springiness was decreased by increasing the level of QF. Springiness, or elasticity, is the rate at which the compressed sample returned to its original height after the deforming force was removed [45]. Chewiness is the energy required to chew a solid food until it is ready for swallowing. It is determined as the product of hardness, cohesiveness and springiness [43]. Burger prepared with 15% quinoa flour had the minimum chewiness value (0.48N) and the control burger had the highest chewiness value (0.77N). The decrease of chewiness could be meaning the product is easier to chew [38]. These results were in disagreement with AL-Juahimi *et al*. [24] who reported that the chewiness of uncooked meatballs increased with increment of moringa seed flour. Some researchers reported that carbohydrates such as starch and dietary fiber component in the added vegetable sources may interact with water and fat of meat products to form a softer texture thus leading to a change in textural properties [42]. Also, Feng and Xiong reported that the interactions between meat and nonmeat additives may effectively affect the gel properties in emulsified meat products through modifying the product texture. Addition of QF in beef burger samples leads to decrease in the resilience index values, especially in samples prepared with 15% QF.

In conclusion, when quinoa was added as flour, hardness, cohesiveness and chewiness ($p<0.05$) of burger decreased, which could be related to the easier and better integration of quinoa flour (with respect to quinoa seeds or co-product) in the meat matrix. Other studies have reported that texture parameters were affected by the incorporation of non-meat ingredients to the meat product formula, since it could modify the interaction between

Table 8: Sensory evaluation of different beef burger samples.

Samples	Color	Taste	Odor	Texture	Appearance	Overall acceptability
C	$9^{a}.0\pm0.98$	$8.8^{a}\pm0.68$	$8.4^{a}\pm0.90$	$8.4^{a}\pm0.11$	$8.7^{a}\pm0.17$	$8.7^{a}\pm0.91$
Q1	$8.8^{a}\pm1.04$	$7.9^{b}\pm0.85$	$8.3^{a}\pm0.97$	$8.2^{a}\pm0.76$	$8.6^{a}\pm0.66$	$8.4^{ab}\pm0.26$
Q2	$8.3^{b}\pm1.10$	$7.3^{bc}\pm0.45$	$7.7^{ab}\pm0.24$	$7.7^{ab}\pm0.89$	$7.8^{b}\pm0.80$	$7.9^{b}\pm0.95$
Q3	$8.1^{b}\pm0.62$	$6.9^{c}\pm0.71$	$6.3^{b}\pm0.72$	$6.8^{b}\pm0.58$	$7.5^{b}\pm0.72$	$7.3^{c}\pm0.72$

*Means at the same column followed by different letters are significantly different at ($P\leq0.05$)

protein–water and protein-protein, and also by the water and oil binding ability of the fiber-rich ingredient added [47].

Some researchers reported that carbohydrates such as starch and dietary fiber component in the added vegetable sources may interact with water and fat of meat products to form a softer texture thus leading to a change in textural properties [38]. Similar results have been reported the use of some ingredients such as oatmeal, rice bran [48, 49 and 50].

Sensory Characteristics of Beef Burger Prepared with Different Ratios of Quinoa Flour: According to the means given by the panelists of cooked beef burger samples, sensory scores for studied parameters such as color, taste, odor, texture, appearance and overall acceptability were varied and affected significantly by the addition of QF Table 8.

The obtained data shows that there was a significant difference in texture between the control samples and samples prepared with (10 and 15%) ratios of QF. Control sample had the highest value of texture compared with the samples contain QF. Also, data in the table shows that there was a significant difference in taste between control samples and samples prepared with 5, 10 and 15% quinoa and these treatments had a score lower than the control treatment. As for the odor parameter, there were significant differences between the control and other treatments (10 and 15%) quinoa flour treatment. Color and appearance also were evaluated by the panelists and there were significant differences in color between the control and quinoa treatments and there were significant differences in appearance among the control and (10 and 15%) quinoa treatments. The data at the same table indicated that there are significant differences ($P<0.05$) among color, taste, odor, appearance and overall acceptability of beef burger substituted with control and 5, 10 or 15 % QF. With regard to the Overall acceptability, the sample containing 15 % of QF was the lowest acceptable sample.

CONCLUSIONS

This research demonstrates a strategy for producing new meat product formulation using some cereals as sources of high quality protein. Production of beef burgers with quinoa flour improving the nutritional quality of burgers without affecting the quality characteristics. Additionally, use of quinoa flour lowered total volatile nitrogen and inhibited lipid oxidation of samples. Furthermore, it progresses a very good quality attributes for cooking properties without negative effect on sensory properties of beef burger and so it could be recommended as a potential component in beef burger production especially the functional one which could be advanced for people suffering from favism. Quinoa seeds may be desirable to meat producers as inexpensive substitutes for traditional additives in meat products.

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