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The Usage of Quinoa Flour as a Potential Ingredient in Production of Meat Burger with Functional Properties

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ABSTRACT

The objective of this study was to investigate the effect of utilizing Quinoa flour (QF) as a potential ingredient in producing functional beef burgers instead of soybean flour (SF). Effect of replacing SF with three concentrations of QF (5, 10 and 15%) on the quality characteristics of beef burger was studied. The incorporation of QF into beef burger processing resulted in enhancing both moisture and fat contents of raw and cooked beef burger. Also, treatments contained QF had recovered water and fat retention, producing beef burger patties with a good cooking and sensory properties strengthened more than those of both control and soy containing treatments, which allowing to use mustard flour in processing of meat products as a binder on the above mentioned replacing level without any detrimental effect on the quality of the product. As well as the level of QF increased, the patties had high lightness (L*) and yellowness (b*) values but low redness (a*) value. The results indicated that quinoa seed flour recommended to be a high potential non-meat ingredient for utilize in producing of functional beef burger in addition to its health and nutritional benefits.

Key words: Quinoa flour, Beef burger, Soybean flour, Meat extender, Cooking properties, Texture, Color.

Introduction

Human health have become increasingly important with the advents of rise of metabolic disease. Food can play a stronger role in disease treatment and prevention and so, more focus has been directed toward the emerging of the healthiest ingredients in our food products. The addition of non-meat ingredients not only improve the quality of the meat products, but also reduce the cost and have beneficial health effects on consumers (Abdolghafour and Saghir, 2014).

Meat extenders is one of non-meat ingredients which added to the meat products formulation to lower the cost of products. Soy protein is the most widely used vegetable protein as a meat extender in meat products because of its high biological factors as well as good functional properties which lead to increase the water binding capacity and thus improve the texture and the acceptability of the final product (Farkas *et al.*, 1998, Passos-Maria and Kuaye, 2002). However, it was found that soya food or any food containing soya is forbidden for people who suffer a kind of genetic disorder called favism (hemolytic anemia) as purported by Acero (2012).

Quinoa (*Chenopodium quinoa*) is an incredibly nutritious grain-like food crop which provide nutrition to Andean indigenous cultures for thousands of years and now plays an increasing role in human diets worldwide. Quinoa has been promoted as an alternative agricultural crop due to its stress-tolerant characteristics and marketed as a "superfood" for its nutritious qualities. The nutritional excellence of quinoa has been recognized for its nutritional benefits i.e protein, mineral, and vitamin. In fact, the protein content represents 14–20%, it has a good balance of the amino acids that make up the protein where particularly rich in essential amino acids such as lysine and methionine and so supplying a high-quality protein. Moreover, it is also a good complement for legumes, which are often low in methionine and cysteine. It also contains large amounts of carbohydrates, fat, vitamins, and minerals (Matiacevich *et al.,* 2006) and found to have a relatively high quantity of vitamins like riboflavin (B2) and α-tocopherol than rice, barley and wheat (Valencia-Chamorro, 2003). Quinoa was found to be a good source of minerals where it contains more calcium, magnesium, iron, and zinc than

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common cereals and its seed lipids appear to be a high quality edible vegetable oil, similar in the fatty-acid composition to soybean oil (Comai *et al.,* 2007).

Quinoa can be eaten as a rice replacement, as a hot breakfast cereal, or can be boiled in water to make infant cereal food. The seeds can be ground and used as flour in making bread, noodles, biscuits and pasta (Valencia-Chamorro, 2003). In the last decade, the use of pseudocereals was increased not only in special diets for people allergic to cereals, but also in healthy diets (Gorinstein *et al.,* 2008). Nowadays, quinoa is receiving considerable attention as an alternative crop in the World (Caperuto *et al.,* 2001). Quinoa is promoted as an extremely healthy food of the future (gluten free). It is a food of the twenty-first century (Valencia-Chamorro, 2003).

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 "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 (FAO, 2013).

With the growing interest in quinoa's nutritional and medicinal value, methods for producing, concentrating, and/or utilizing several value-added products from quinoa have been developed over the past 25 years (Graf *et al*., 2015).

Therefore, the aim of this study is to determine the nutritional value of dried quinoa seeds planted in Siwa Oasis, Egypt. Also, assessment the effects of adding quinoa flour as a replacement of soybean flour on the quality parameters of processed functional beef burger.

Material and Methods

Materials:

The quinoa seeds were obtained from Khmisa Farm, Siwa Research Station, Desert Research Center-Egypt. the seeds were washed with cold water for several time in order to remove possible saponin residues then dried in an electric oven at 50°C. The quinoa seeds were ground into powder using a high-speed blender mill (25000/min), (WK-1000A; Qing Zhou Machinery Co., Ltd.), and then stored in polyethylene bags at 4°C until analysis. Four kilograms of boneless grounded beef meat (lean meat) were purchased from a local butcher shop in the day before the experiment in this investigation was done and stored in a refrigerator at 5±1°C overnight. Soybean flour (SF) containing 48% protein was obtained from Food Technology Research Institute, Agriculture Research Center, Giza, Egypt. The rest ingredients of beef burger (spices, white and black pepper, onion powder, garlic powder and salt) were obtained from the local market, Giza.

Sample preparation:

Five blends were prepared as shown in Table (1) as follows:

- 5% of the meat were replaced by 5% quinoa flour (QF5%).
- 10% of the meat were replaced by 10% quinoa flour (QF10%).
- 15% of the meat were replaced by 15% quinoa flour (QF10%).
- 10% of the meat were replaced by 10% Soybean flour (SF%).
- 100% minced meat as a control sample.

Each blend was mixed with all ingredients and formed into beef patties using a burger forming machine (Expro. Co., Shanghai, China) with a diameter of 8 cm. The beef patties were cooked for 20 min in a pre-heated hot-air oven at 180 ± 1°C to an internal temperature of 75°C measured at the geometrical center using a digital probe thermometer (Oakton, Eutech Instruments, China), to ensure a uniform cooking. Then the beef patties were turned over at 10 min intervals. Three sample replicates from each blends were evaluated for their quality attributes.

Proximate Analysis:

The quinoa flour (QF) samples were analyzed for moisture, crude protein, ether extract, crude fiber and total ash according to the methods described in the A.O.A.C. (2000). The carbohydrate content was determined by subtracting the total crude protein, crude fiber, ash and fat from the total

dry weight (100g) of the food (calculated by difference). Moisture and fat contents of both raw beef burger (RBB) and cooked beef burger (CBB) were performed using Food Scan™ Pro meat analyzer (Foss Analytical A/S, Model 78810, Denmark), Cairo University Research Park (CURP), Faculty of Agriculture, Cairo University.

Table 1: Ingredients (%) of formulated five blends of beef burgers.

Ingredients	Quinoa flour (%)				
	Control	SF	QF (5%)	QF (10%)	QF (15%)
Lean meat	71.0	61.0	66.0	61.0	56.0
Added fat	10.0	10.0	10.0	10.0	10.0
Cold water	15.4	15.4	15.4	15.4	15.4
Salt	1.0	1.0	1.0	1.0	1.0
White pepper	0.2	0.2	0.2	0.2	0.2
Black pepper	0.2	0.2	0.2	0.2	0.2
Garlic powder	0.2	0.2	0.2	0.2	0.2
Onion powder	2.0	2.0	2.0	2.0	2.0
SF	0.00	10.0	0.00	0.00	0.00
QF	0.00	0.00	5.0	10.0	15.0

(SF) is treatment with soybean flour, (QF5%) is treatment with 5% quinoa flour, (QF10%) is treatment with 10% quinoa flour and (QF15%) is treatment with 15% quinoa flour.

Determination of cooking properties:

The cooking yield was determined as reported by Naveena *et al.* (2006) as follows:

$$\text{Cooking yield} = \frac{\text{Weight of cooked burger}}{\text{Weight of raw burger}} \times 100$$

Based on the method of El-Magoli *et al.* (1996), the moisture retention was determined as follows:

$$\text{Moisture retention} = \text{Cooking yield} \times \frac{\text{\% Moisture in cooked}}{\text{\% Moisture in raw burger}}$$

Fat retention was calculated according to Murphy *et al.,* (1975) as follows**:**

$$\text{Fat retention} = \text{Cooking yield} \times \frac{\text{\% fat in cooked burger}}{\text{\% fat in raw burger}}$$

The diameter of each treatment was measured before and after cooking with a digital caliper. Changes in diameters were determined using the following equation as mentioned by Modi *et al.* (2004) as follows:

$$\text{Diameter reduction (\%)} = \frac{\text{Raw burger diameter- Cooked burger diameter}}{\text{Raw burger diameter}} \times 100$$

Color measurement:

The color of Cooked beef burger patties was measured by Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer at Cairo University Research Park (CURP), Faculty of Agriculture. Color was expressed using the CIE L, a, and b color system (CIE, 1976). A total of three spectral readings were taken for each sample on different locations of the LD muscle. Lightness (L*) (dark to light), the redness (a*) values (reddish to greenish). The yellowness (b*) value (yellowish to bluish) was estimated.

Shear force:

The shear force (kgf/cm^3) was estimated using Instron Universal Testing Machine (Model 2519-105, USA) at Cairo University Research Park (CURP), Faculty of Agriculture. Six test from each sample were taken. The shearing machine was adjusted at crosshead speed of 200 mm/min.

Sensory evaluation:

Sensory evaluation was carried out by ten panelists at Agricultural Industrialization Unit - Desert Research Center – Cairo –Egypt. The panelists were asked to evaluate appearance, color, taste, tenderness, juiciness, flavor, texture and overall acceptability using 10-point scale for grading the quality of samples as described by Kassem and Emara (2010).

Statistical analysis:

All analyses were performed in triplicate and data reported as mean ± standard deviation (SD). Data were subjected to analysis of variance (ANOVA) ($P<0.05$).

Results and Discussion

From results presented in table (2) it could be noticed that the moisture and ash contents of QF were 10.40% and 1.6%, respectively. These values found to be lower for moisture content and in accordance for ash contents obtained by (Abugoch *et al.* 2009) who found that moisture content and ash content of QF were 11.8% and 1.6%, respectively.

Ether extract content of QF (6.88%) was found to be higher than value observed by Demir (2014) who found the QF had 4.86% of fat content.

The crude protein content of QF was 13.54% which found to be slightly lower than those obtained by Abugoch *et al.* (2009) who state that the protein content of QF was 14.2% but it located in the range percent mentioned by Valencia-Chamorro (2003) who illustrated that the protein content of quinoa seeds varies from 8% to 22%.

Crude fiber content of quinoa seed flour was 4% which was slightly higher than that value determined by Demir (2014). The QF had carbohydrates content 63.58% which was to be comparable with the carbohydrate range (58.1% to 64.2% of dry seed weight) as mentioned by Bhargava *et al*., 2006.

Table 2: Proximate analysis of quinoa flour.

Proximate analysis	Quinoa Flour (g/100g)
Moisture	10.40
Total Ash	1.60
Ether extract	6.88
Crude Protein	13.54
Crude Fiber	4.00
Total Carbohydrates	63.58

Effect of quinoa flour on moisture and fat percentage of beef burger:

Results in figure (1) showed that the moisture content of RBB decreased in all treated samples in comparison with the control, the highest significant decrement percentage found with the SF treatment. In contrast, the moisture content of CBB decreased also, but the rate of decrement was significantly high with the control and SF treatments compared with the QF treatments, where the decline rate was found to be not significant between the levels of QF. Our results were found to be in the same trend with those obtained by Al-Juhaimi *et al.* (2015) who use the moringa seed flour as a binder in beef burgers. Serdaroglu (2006) reported a decrease in moisture content of beef patties formulated with oat flour due to an increase in solid contents. furthermore, Alakali *et al.* (2010) stated that the increasing in bambara groundnut seed flour percentage decreased the moisture content of beef patties.

The fat content significantly decreased in the CBB for both SF and control treatments. On the other hand, the fat content slightly decreased in QF5% treatments and increased in both QF10% and QF15%. Cooking may be cause an increase in dry matter content by losing water and water soluble constituents with a concomitant increase in fat contents as reported by Alakali *et al.* (2010) for beef patties formulated with bambara groundnut seed flour. Also, a similar trend has been observed by

Dzudie *et al.* (2002) for beef patties extended with common bean flour and in beef patties of buffalo meat prepared with different legume flours (Modi *et al*., 2004).

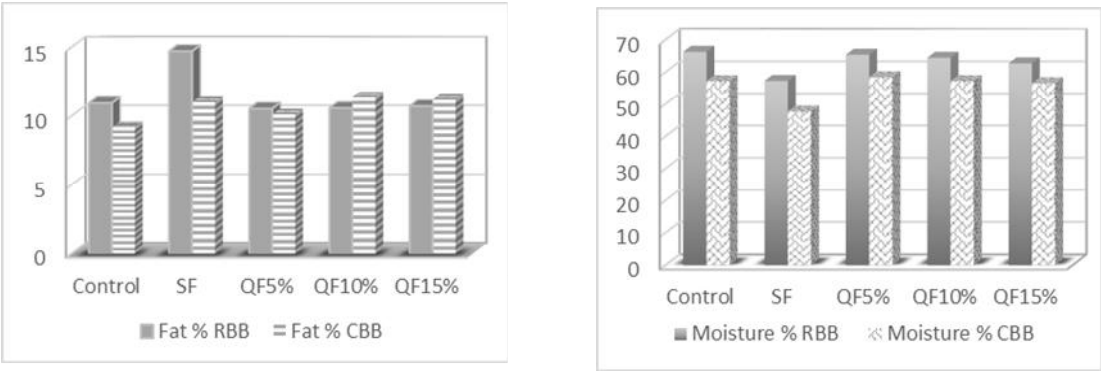

Fig. 1: Moisture and fat percentages in RBB and CBB samples.

It has been reported by (Sheridan and Shilton, 2002) that during cooking, beef burger patties lose moisture content through drip and which subsequently evaporate, meanwhile, addition of QF to the beef burger lead to reduce the drip and evaporation that resulting in avoiding losing both moisture and fat content in CBB.

Effect of quinoa flour on cooking properties of beef burger:

Cooking properties such as cooking yield, moisture, fat retention and diameter reduction are some of the most important factors for meat industry in order to predict the behavior of products during cooking. Figure (2) shows the effect of QF on cooking yield, moisture, fat retention and diameter reduction of beef burger. There was a significant increment in the cooking yield values where it increased from 59.20% and 71.21% for control and SF treatments to 72.03%, 80.06% and 85.93% for the QF5%, QF10% and QF15%, respectively. Similar results were obtained with Alakali *et al.* (2010) for the cooking yield in beef patties formulated with bambara groundnut seed flour and with Ammar, (2012) who illustrate that the cooking yield increased with increasing level of mustard flour incorporated in beef burger

Moisture retention in ground meat products is an important cooking parameter, since retained moisture in the product effects eating quality and it represent the amount of moisture retained in the 100 g cooked product. The moisture retention of CBB increased with the QF treatments compared with the control (59.2%) and SF (71.21%) treatments where the values were 77.495%, 71.019% and 64.332% for QF15%, QF10% and QF5%, respectively. Also, the same trend of results for moisture retention were observed with fat retention in CBB. The lowest fat retention values were 51.081% and 59.182% for both control followed by SF treatments, respectively, while the highly significant values obtained with QF15%, QF10% and QF5% were 89.642%, 86.046% and 69.138%, receptively.

Our results were in accordance with those obtained by Alakali *et al.* (2010) who reported the same results for cooking yield in beef patties formulated with bambara groundnut seed flour, and with Al-Juhaim *et al.* (2015) who found that the addition of moringa seed flour recover both moisture and fat retention in cooked beef burger. Also, Serdaroglu (2006) advertised an increases in fat retention for Turkish type meat balls formulated with different levels of corn flour. Finally, high retention of both water and fat, positively influences characteristics such as texture and juiciness of meat products (Selani *et al.*, 2015). Ammar, (2012) stated that moisture retention and fat retention values of beef burger samples increased with replacing soy flour with mustard flour, also the values of moisture and fat retention were increased with increasing level of mustard flour in beef burger samples.

The increase in moisture and fat retention may be due to the swelling of the starch and fibre as mentioned by (Modi *et al.*, 2004), as well as the fat absorbed by the fibre may interact with the protein of the ground meat matrix to prevent migration of fat from the product (Alakali *et al.*, 2010).

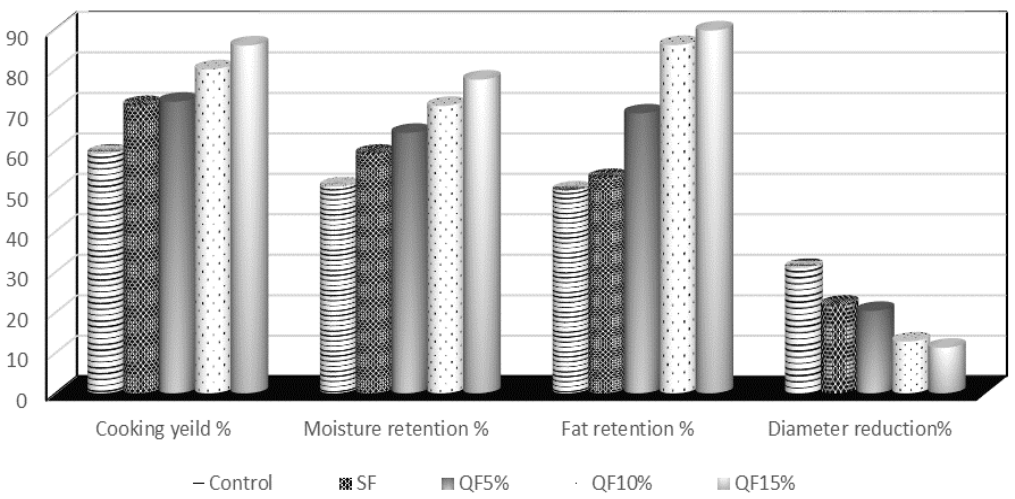

Fig. 2: Effect of quinoa flour on cooking properties of beef burger.

A dimensional change is one of the most important alterations of beef patties which can be affected by incorporation of new ingredients (Soltanizadeh and Ghiasi-Esfahani, 2014). Differences in diameter between burgers were statistically significant. As the percentage of QF in beef burger increased the reduction in burger diameter decreased. The diameter reduction value of SF treatment (21.875%) has been higher than those values obtained with QF treatments. The lowest value of diameter reduction percentage was (11.239%) obtained with the QF15% treatments followed by QF10% and QF5% which were 12.791% and 20.349%, respectively, where the highest diameter reduction value found to be with the control treatment (31.008%).

Effect of quinoa flour on color of beef burger:

In meat and meat products color considered to be an important quality attribute and one of the main factors determining the acceptability of the consumer, which can be influenced by the presence of non-meat ingredients (Hunt and Kropf, 1987**)**

Results in figure (3) showed that there was a significant increment in both lightness (as measured by the L* value) and yellowness (as measured by b* value) as the QF percentage increased. The maximum values for L* (46.73) and b* (19.19) values were observed with QF15% treatments, where the lowest L* and b* values (41.14 and 14.62), respectively, were obtained with the control treatment and this may be refer to the high level of redness in meat and muscle pigment. Similar results illustrated by Al-Juhaim *et al.* (2015) who announced that there was an increment in the L* and b* values of formulated beef patties as moringa seed flour increased. Also Turhan *et al.* (2007) reported that as wet okra concentration increased, beef patties were lighter. Furthermore, Serdaroglu (2006) advertised that oat flour appeared to increase yellowness in patties when compared with the control samples.

A reduction in a* value has been occurred, where the more reduction appeared with treatments contain QF followed by the control then the SF treatment. There was no significant difference in the a* value between the QF treatments. Our results were conformity with chicken beef patties formulated with finger millet flour (Naveena *et al.,* 2006), low-fat meatballs formulated with whey powder (Serdaroglu, 2006) and formulated beef patties contained moringa seed flour (Al-Juhaim *et al.,* 2015).

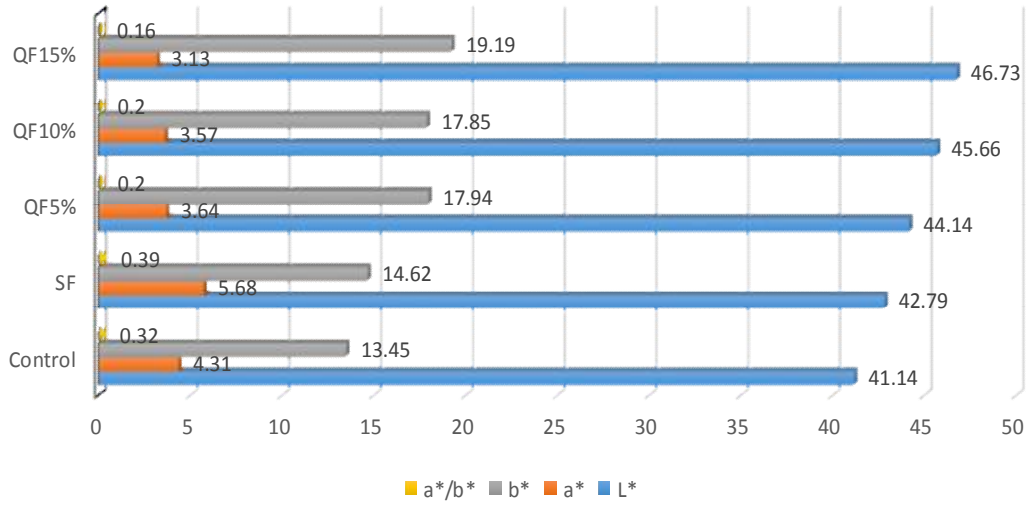

Fig. 3: Effect of quinoa flour on color parameters of beef burger.

The a*/b* value is commonly used as an index to report the color quality (brightness of red color). The increase in the b* value compared to the a* value resulted in an overall decrease in the a*/b* values of QF treatments. This mean that the QF treatments had a significant effect on color quality (brightness of red color) of the patties as indicated by low a*/b* values (Al-Juhaim *et al.,* 2015).

Effect of quinoa flour on shear force of beef burger:

Shear force was taken as a hardness indicator. It was found that there was a change in hardness characteristic within our treatments. Figure (4) display a greatest hardness for both control and SF treatments where the QF5%, QF10% and QF15% appeared to had the lowest force value and so a less hardness. Thus, QF affected the mechanical properties and provide the final product its characteristic of juiciness and better texture. This results were to be on the same line with those obtained by Bastos *et al.* (2014) who develop a type of hamburger meat product using oatmeal flour, flour of green banana pulp, flour of green banana peel, flour of apple peel and pulp of Green Banana as fat substitutes.

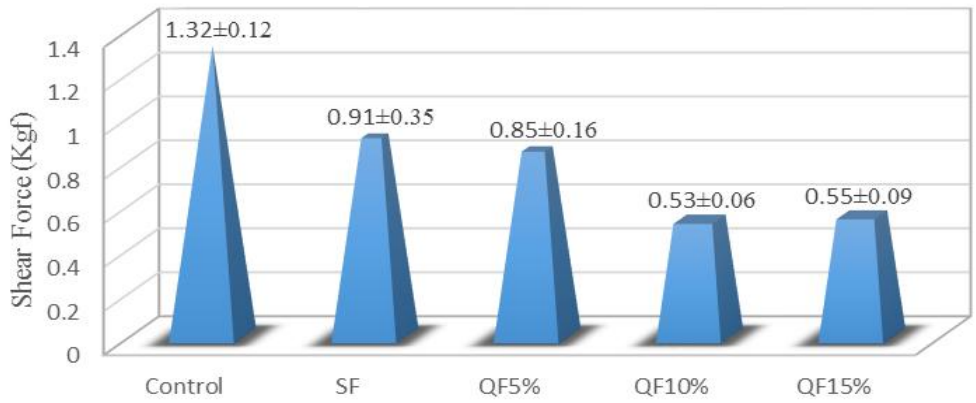

Fig. 4: Effect of quinoa flour on shear force of beef burger.

These results corroborate those of the existing literature, which reported that some substitutes may provide better texture to products made with ground beef because these ingredients absorb water, dissolve with the meat protein matrix and result in increased softness of the product (Mansour and Khalil 1997; Khalil 2000; Aleson-Carbonell *et al.* 2005; Anderson and Berry 2000).

Effect of quinoa flour on sensory properties of beef burger:

Figure (5) shows the results of sensory evaluation results of beef burger treatments. Data show that there were no significant differences between beef burger treatments for color, taste and odor but there was a significant difference between control, SF treatments and the QF treatments for texture, tenderness and juiciness. The treatments containing QF exhibit an excellent sensory acceptance especially the texture, tenderness and juiciness which appeared to be reinforcement by adding QF to the beef burger which reflect the ability of using QF as a meat ingredient without negatively affecting the sensory properties of beef burger patties.

Ammar, (2012) concluded that the incorporation of mustard flour into beef burger patties instead of soybean flour had no negative effect on sensory properties of beef burger. Where Al-Juhaim *et al.* (2015) declared that the sensory characteristics of cooked beef patties formulated with moringa seed flour have acceptable sensory scores.

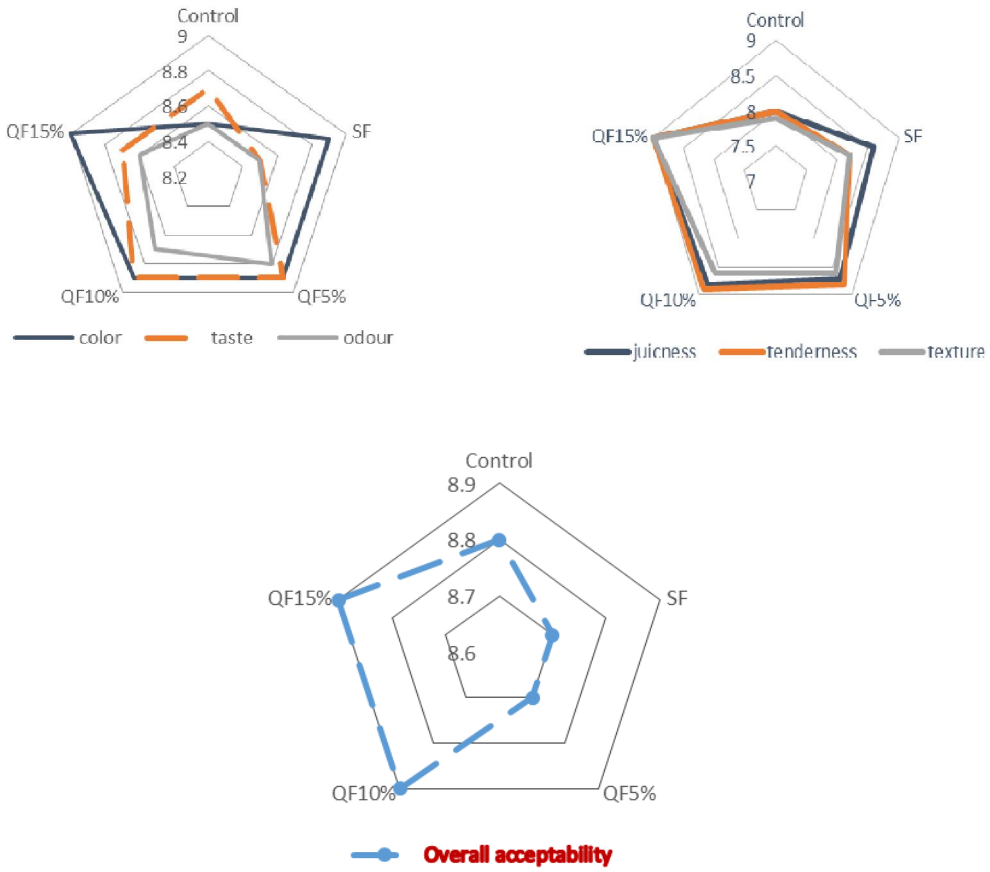

Fig. 5: Effect of quinoa flour on sensory properties of beef burger.

Conclusion

Based on the findings, the quinoa flour used in this study considered to be an effective additive showing improvement in moisture and fat contents in both raw and cooked beef burger. Furthermore, it progresses a very good quality attributes for cooking properties, color without

negative effect on sensory properties of beef burger and so it could be recommended as a potential component in beef burger production instead of soybean flour especially the functional one which could be advanced for people suffering from favism.

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