Preparation of Beef Burger Supplemented with Quinoa Seeds Powder as Healthy Food

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Abstract

This study was conducted to identify the possibility of preparing meat burgers by adding quinoa seeds powder and its quality characteristics. Therefore, the aim of this study was to assess the effects of quinoa seeds powder (QSP) in improving the quality characteristics of raw and cooked beef burgers. The effects of quinoa seeds powder addition (2.5, 5, 7.5, and 10%) on physicochemical properties, cooking parameters, color, texture, and sensory evaluation of cooked burgers were evaluated. Furthermore, via a biological study, the impact of dietary supplementation with quinoa seeds powder (QSP) on hyperlipidemic rats were also determined. The nutritional parameters, including food intake, weight gain or mass increase, and feed efficiency ratio, were recorded. Additionally, the triglycerides, cholesterol profiles, liver and kidney functions were measured. The incorporate QSP into the beef burger. The use of QSP in raw and cooked beef burgers resulted in an increment L* and b* and a decrement in a* values at all levels (P<0.05). Texture analysis showed that with the addition of QSP, the hardness values of burgers increased, and adhesiveness values decreased. regarding to the taste; flavor; color, and overall acceptability sensory evaluated, no significant differences (P < 0.05), among the tested fortified burger at all levels of QSP, in relative to the control, were detected. From the obtained results, the rat groups fed on the high-fat diet were significantly suffering from risk of hyperlipidemia. However, the results indicated that all the fortified diets at different levels improved the weight gain and feed consumption, reduced lipid profiles, and improved liver and kidney functions, in relative to positive control group. More specifically, a diet with 10% QSP reduced the adverse effect of hyperlipidemia. Therefore, these new beef burger
formulations might be a viable option for the improvement of nutritional, technological, and sensory properties.

**Keywords**: Quinoa Seeds Powder, Beef burger, Antioxidant, Dietary Fiber, Functional food

1-INTRODUCTION

Recently, the consumer’s awareness of the importance of eating healthy food has changed, considering that the food is not only for satiation but also for health benefits. Therefore, it has tended to increase the intake of functional foods rich in ineffective compounds that satisfy the body’s needs of essential nutrients and give it the ability to resist diseases (Küster and Vila, 2017). Seeds and sprouts are excellent examples of "functional food", which is defined as reducing the risk of various diseases and promoting health, in addition to its nutritional value (Pásko et al., 2009). Quinoa is one of the crops that has more attention due to its important nutritional components and its high levels of fatty acids, vitamins, minerals, dietary fiber, and proteins that contain more amino acids (Pellegrini et al., 2018). In addition, it contains a large variety of bioactive compounds such as polyphenols, flavonoids, carotenoids, and vitamin C which have been shown in many studies to be protective against a variety of diseases, especially cancer and allergies, inflammatory diseases, and may reduce the risk of cardiovascular diseases. It has been cultivated for centuries in the Andean countries of Peru, Bolivia and Egypt. However, its cultivation has spread at present in many countries, such as Australia, Canada, China, England, the Middle East, and others due to its wide genetic diversity that allows it to adapt to different environments (Pereira et al., 2019).

Quinoa differs from wheat grains in the absence of gluten and higher content of lysine (5.1-6.4%), methionine (0.4-1.0%), contents (Bhargava et al., 2003). Quinoa contains lysine, methionine and cysteine higher than common cereals and legumes making it complementary to these crops and cysteine (Elsohaimy et al., 2015), and quinoa proteins also have good functional properties, for example, emulsification, foaming, solubility, (Kaspchak et al., 2017).

Fortification of food products with quinoa is one of the methods for developing functional foods, as quinoa seeds powder has been used in the manufacture of various foods such as bread, baby food, chips, and beer, but studies on the use of quinoa seeds powder in the manufacture of meat and its
various products such as burgers are still limited. Beef burger is one of the most popular meat products that is widely used as a ready meal (Heck et al., 2017) although it contains high levels of fat, cholesterol, and sodium which has led to an increased prevalence of chronic diseases, including colon cancer, obesity, and cardiovascular disease and many other disorders (Selani et al., 2016). According to the World Health Organization (2020), total fat intake must be less than 30% of total body energy to prevent the risk of chronic disease. (Patinho et al., 2019) using Agaricus bisporus as a partial fat substitute improves the organoleptic quality and preserves the potent properties of a beef burger. Quinoa or buckwheat seeds powder is also used as a substitute for both soy protein and bread crumbs in the traditional burger formula (Pellegrini et al., 2018). Therefore, the present study aims to evaluate the physical, chemical, nutritional, and sensory properties of beef burgers that contain quinoa seeds powder as a partial substitute for fat.

2. Materials and Methods

Methods

Quinoa (Chenopodium quinoa Willd L.) seeds were purchased from the Field Crops Research Institute, grain Department Agricultural Research Center, Giza, Egypt. Beef and fat were purchased from the local market, Shebeen El Koom, Egypt. Experimental animals were purchased from Helwan farm of Laboratory Animals, Helwan, Egypt. Kits for measurement of biochemical parameters were purchased from Sigma Aldrich Chemical Co., (St. Louis, MO, USA). The rest of all other chemicals and reagents were obtained from El-Gomhoreya Company, Cairo, Egypt.

Preparation of Quinoa seeds

Quinoa (Chenopodium quinoa Willd L.) Seeds were washed with distilled water (at 37 °C) in the ratio of 1:2 (quinoa seeds: distilled water). This procedure was performed twice, and then the quinoa seeds were soaked in distilled water for 20 min. After that, the quinoa seeds were dried at 40 °C for 12 hours in a hot air oven. The dried quinoa seeds were milled to obtain powder by using a laboratory hammer mill (Retsch, Germany). The flour was passing through 60 mesh sieves and kept in a polyethylene bag at 10 °C until utilization and analysis.
Determination of Total phenols, Flavonoids, and DPPH.

Extracts were prepared by adding 25 ml methanol to one gram quinoa seeds powder. This mixture was left on the shaker for 24 hours, after that the mixture was centrifuged (10000 RCF for 15 min) and the supernatant was filtrated by watman No 41 filter papers. The supernatant was adjusted to 25 ml by adding methanol, kept in the refrigerator (4 °C).

Total Phenol content was determined by the Folin–Ciocalteu micro-method according to (Wu, et al., 2007). Flavonoid content was determined by the modified method of (Baba and Malik, 2015) using of methanol instead of ethanol in crude extract.

The DPPH assay according to (Park et al., 2017) was utilized with some modifications by using methanol instead of ethanol in crude extract. Scavenging activity was calculated as follows:

\[
\text{DPPH radical-scavenging activity (\%) = \left(\frac{Ab \text{ control} - Ab \text{ sample}}{Ab \text{ control}}\right) \times 100}\]

where Ab is the absorbance at 515 nm.

Preparation of beef burger.

Preparation of beef burger was carried out according to Troutt et al., (1992). Briefly, the lean beef was mixed with 15 % fat for 15 min as a control. Then, the mixture was homogenized in Braun Cutter Machine (Combimax 700, USA) at 4 °C for 12 h and shaped as discs using a metal shaper. The diameter and thickness of the disc were 8 and 1 cm, respectively. Each disc was covered by polyethylene film and kept in freezing at 18 °C. Beef burger was formulated by replacing of fat in control by different levels of Quinoa seeds powder (Table 1).

Table 1. The percent of Ingredients in the beef burger (g/100g).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>control</th>
<th>2.5%</th>
<th>5%</th>
<th>7.5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat (%)</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>Onion (%)</td>
<td>15.5</td>
<td>15.5</td>
<td>15.5</td>
<td>15.5</td>
<td>15.5</td>
</tr>
<tr>
<td>Salt (%)</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>Beef burger Spices</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
</tr>
</tbody>
</table>
Animal Fat (%) | 15 | 12.5 | 10 | 7.5 | 5  
---|---|---|---|---|---
Quinoa seeds powder (%) | - | 2.5 | 5 | 7.5 | 10

Cooking of the beef burger.

The samples of the beef burgers were cooked according to the method described by Ou and Mittle (2006). Beef burger was cooked by an electrical grill at 180 °C for 10 min. (each side 5 min). Cooking yield and diameter of burgers in every batch before and after cooking were determined (Aleson-Carbonell et al., 2005), then cooking yield, moisture retention, and fat retention was calculated according to the following equations (El-Magoli et al. 1996).

Cooking yield (%) = \( \text{Cooked beef weight} \times 100 \div \text{Raw beef weight} \)

Moisture retention (%) = \( \left( \frac{\text{Cooked weight} \times \% \text{ Moisture in cooked}}{\text{Uncooked weight} \times \% \text{ Moisture in uncooked}} \right) \times 100 \)

Fat retention % = \( \left( \frac{\text{Cooked weight} \times \% \text{ Fat in cooked}}{\text{Uncooked weight} \times \% \text{ Fat in uncooked}} \right) \times 100 \)

Chemical analysis

Proximate chemical composition

Moisture, protein, fat, fiber, and ash contents of raw samples were determined according to the methods of A.O.A.C., (2000). Total carbohydrates were calculated by the difference. All proximate composition experiments were performed in triplicate and expressed as g/100 g of burger.

Water holding capacity

Water holding capacity (WHC) of meat tissues was measured according to the method described by (Honikel, 1998). The meat tissues (0.3g) were carefully flattened in a glass plate and covered with shell filter paper (whatman No. 41) then pressed for 10min using a mass of one kg weight. Two zones were formed on filter paper, their surface area was measured using a planimeter. The WHC was calculated as cm²/0.3g by subtracting the area of the internal zone from that of the outer.
Color Measurements

The color of cooked burger samples was measured at room temperature using a hand-held chromameter (model cR-400, Konica Minolta, Japan) and CIE-1-AB parameters ($L^*$, $a^*$ and $b^*$) were determined. The results were expressed in terms of $L^*$ (lightness), $a^*$ (redness-greenness) and $b^*$ (yellowness-blueness) according to the methods described by (McGurie., 1992).

Texture profile analysis

The texture was determined in Food Technology Research Institute, Agricultural Research Center Giza- Egypt, by a universal testing machine (Cometech, B type, Taiwan). An Aluminum 25 mm diameter cylindrical probe was used in a “Texture Profile Analysis” (TPA) double compression test to penetrate to 50% depth, at 1 mm/s speed test. Hardness (N/cm$^2$), gumminess (N/cm$^2$), chewiness (N/cm$^2$), cohesiveness (ratio), and springiness (cm) were calculated from the TPA graphic. Both springiness was calculated from the TPA graphic as described by (Al-Farsi., 2005) and (Al-Mahrouqi., 2009).

Sensory evaluation

Sensory evaluation was carried out by 25 staff members of Food Technology Research Institute Giza, Egypt. Fresh samples of burgers cooked were in an electric grill (SBG-7110, Sinbo, t 180 ° C) for 7--8 minutes per side (until the internal temperature reached 73--75 ° C) and served warm to team members with randomly coded numbers. Members were asked to rate the samples containing, 0.0, 2.5, 5.0, 7.5, and 10% burgers evaluated according to the procedure of Lamond (1973) Panelists were asked to score the color, odor, Texture, Taste, Appearance, and overall acceptability properties according to 20-points hedonic scale.

Biological Experimental Design

Table 2 represents the composition of the experimental diet (%) according to Kim, et al., (2009). Sixty Male Albino (100-110g) rats were individually housing in cages at room temperature. The rats were left to acclimatize for one week before the start of the experiment. The rats were divided into six groups 10 rats each. The first group was fed on the normal diet without quinoa seeds powder (negative control). The second group was fed on a high-fat diet (positive control). The third group to sixth groups were fed on the high-fat diet with different addition of quinoa seeds powder 2.5, 5, 7.5,
and 10% respectively for 35 days as shown in Table 2. The rats were ad-libitum food and water intake during the experimental period. Body weight was recorded weekly and body weight gain was calculated by the difference between initial and final weight. Feed efficiency ratio was calculated as gram feed /gram gain. Collection of the blood samples from the retro-orbital plexus of the eyes for all animals. Getting the plasma blood samples by centrifugation at 3000 rpm for 15 min at room temperature and kept at -5 ºC tell analysis.

### Table 2. Compositions of the experimental diet (%)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Corn starch</th>
<th>Casein</th>
<th>Corn oil</th>
<th>Cellulose</th>
<th>Salt</th>
<th>Vit</th>
<th>Oil</th>
<th>Quinoa</th>
<th>Choline</th>
</tr>
</thead>
<tbody>
<tr>
<td>G 1 (Control)</td>
<td>65</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>3.8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td>G 2 (High fat diet)</td>
<td>55</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>3.8</td>
<td>1</td>
<td>10</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td>G 3 (2.5 % QSP)</td>
<td>52.5</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>3.8</td>
<td>1</td>
<td>10</td>
<td>2.5</td>
<td>0.2</td>
</tr>
<tr>
<td>G 4 (5.0 % QSP)</td>
<td>50</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>3.8</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>0.2</td>
</tr>
<tr>
<td>G 5 (7.5 % QSP)</td>
<td>47.5</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>3.8</td>
<td>1</td>
<td>10</td>
<td>7.5</td>
<td>0.2</td>
</tr>
<tr>
<td>G 6 (10 % QSP)</td>
<td>45</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>3.8</td>
<td>1</td>
<td>10</td>
<td>10</td>
<td>0.2</td>
</tr>
</tbody>
</table>

### Biochemical analysis

Plasma was used to determine total cholesterol (TC), total triglycerides (TG), low-density lipoproteins (LDL-C), high-density lipoprotein (HDL-C), and liver enzymes (ALT, AST) by enzymatic methods according to Allain et al. (1974), Fossati and Prencipe (1982), Friedwald et al. (1972), Demacker et al. (1980), and Reitman and Frankel (1957), respectively. Uric acid, Urea Nitrogen, and Creatinine were evaluated according to Fossati, et al., 1980), (Patton and Crouch., 1977), and Heinegård and Tiderström (1973), respectively.

### Statistical analysis:

The obtained data were statistically analyzed using computerized SPSS version 16 (Statistical Package for the Social Sciences). Effects of different treatments were analyzed by one-way ANOVA (Analysis of variance) test using Duncan’s multiple range test and p<0.05 was used to indicate significance between different groups (Bradley and Blackwood, 1989).

### 3. Results and Discussion
Chemical composition of quinoa seeds powder

Table (3) shows the results of chemical composition, of quinoa seeds powder (QSP). The protein, fat, ash, moisture, crude fiber, and carbohydrates, were (15.22 ± 0.35, 4.36 ± 0.17, 3.4 ± 0.02, 12.8 ± 0.31, 7.66 ± 0.42, and 56.56 ± 0.38, respectively). The obtained results indicated that the quinoa seeds powder is a complete functional food, rich in basic nutrients, including dietary fibers and proteins of high nutritional value, and it agreed with the findings of previous studies regarding chemical analysis such as (Sohaimy et al., 2018). The contents of moisture, protein, fiber, and ash was very similar, but the percentage of carbohydrates was higher in the Sohaimy study than in the current study and the results were (9.68% moisture, 14.3% crude protein, 4.6% crude fiber, 2.97% ash), but the content of carbohydrates was about (72.15%).

Abugoch James, (2009) indicate that the average of protein content in quinoa seeds ranges between 12% and 23%. Compared to other cereals, the protein content in quinoa seeds powder is higher than that of barley (11%), rice (7.5%), peanuts (8.8-11.6%), cowpea (8.8-12.1%), and corn (13.4 on the other hand, although Quinoa seeds contain relatively fewer proteins compared to legumes (22.75-37.9%), as indicated (Sohaimy et al. 2018). However, quinoa protein is considered a rich source of bioactive peptides that play a major role in improving overall health (Vilcacundo et al., 2018).

Table (3): Chemical composition of quinoa seeds powder (g/ 100g dry weight)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Quinoa Seeds Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>15.22 ± 0.35</td>
</tr>
<tr>
<td>Fat</td>
<td>4.36 ± 0.17</td>
</tr>
<tr>
<td>Ash</td>
<td>3.4 ± 0.02</td>
</tr>
<tr>
<td>Moisture</td>
<td>12.8 ± 0.31</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>7.66 ± 0.42</td>
</tr>
<tr>
<td>Total carbohydrates</td>
<td>56.56 ± 0.38</td>
</tr>
</tbody>
</table>

Values are the means of three replicates ± SD.

Phenolic, flavonoids compounds, and antioxidants capacity
Natural antioxidants have received more attention in recent years due to their great importance in eliminating free radicals resulting from oxidation reactions of biological compounds in the living tissues of the body (Nsimba, et al., 2008). The formation of free radicals’ compounds in the body that have a harmful effect on human health causes many diseases, like, peroxides that are produced from the oxidation of polyunsaturated fatty acids because of a metabolic disorder in the body's metabolism. Accordingly, the importance of the step of evaluating the effectiveness of antioxidants compounds from plant sources as natural antioxidants that inhibit the oxidation of fats and other vital compounds by inhibiting the initiation step and preventing the formation of active compounds as well as reducing their spread, which speeds up the end-stage and eliminates those free radicals. Also, antioxidants help in maintaining the quality of the food and extending its shelf life (Vega-Gálvez et al., 2010). Quinoa sprouts and seeds have shown high natural antioxidant activity through laboratory tests such as DPPH and ABTS, and this has attracted the interest of many researchers. This is because the seeds and buds contain phenolic compounds that the plant makes to protect it from its natural enemies, which may affect the sensory and nutritional properties of food (Paško et al., 2009).

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Quinoa seeds powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>phenolic mg/100g</td>
<td>18.4</td>
</tr>
<tr>
<td>Flavonoid mg/100g</td>
<td>14.9</td>
</tr>
<tr>
<td>DPPH %</td>
<td>22.73</td>
</tr>
</tbody>
</table>

Values are the means of three replicates

In the current study, the total phenolic content in quinoa seeds powder was 18.4 mg / 100 g (Table 4). For human nutrition, polyphenols play an important role due to their beneficial effects on human health due to their role as antioxidant, anti-inflammatory, anti-microbial and anti-carditis.
Polyphenols also play a critical role in the prevention of neurological diseases and diabetes (IT, 2005). Flavonoids are organic compounds belong to polyphenols (flavonols, flavones, flavanones, isoflavones, catechins, anthocyanidins and chalcones) produced in fruits, vegetables and some cereal crops and are responsible for the color of most fruits and vegetables. In the present study, the total flavonoid content in quinoa seeds powder was 14.9 mg / 100 g (Table 4). In a study (Repo-Carrasco-Valencia and Serna 2011), quinoa is high in flavonoids ranging from 36.2 to 144.3 mg / 100g. The DPPH assay has been widely used to assess the leaching capacity of free radicals for many natural products and has been accepted as a model compound for free radicals that arise in lipids. Table (4) showed that the quinoa seeds powder methanolic extracts activity against DPPH of quinoa seeds powder was 22.73%.

**Cooking measurements of beef burgers containing quinoa seeds powder**

Beef meat grinding to produce beef burger leads to breakdown of muscle fibers and connective tissues with meat, which results in loss of water and fat retention capacity and thus a loss in the yield in final product of the burger (Aleson- et al., 2005). Therefore, cooking measurements such as cooking yield, water and fat retention are the most important variables that are affected with the new ingredient. Addition of QSP in different proportions of 2.5, 5, 7.5 and 10% compared to the standard burger without any additives as a source of dietary fibers in the burger lead to change the cooking measurements due to its ability to retain more moisture and fatty substance, which increases the yield of the burger. Also QSP containing a high percentage of protein that supports meat protein and reduces the effect of the grinding process (Kovácsné Oroszáni et al., 2006). The obtained results are tabulated as in Table (5).

**Table (5). Cooking parameters of beef burgers formulated with of quinoa seeds powder**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cooking yield %</th>
<th>Moisture retention %</th>
<th>Fat retention %</th>
<th>Water-Holding Capacity cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>65.54 ± 0.06</td>
<td>40.46 ± 0.69</td>
<td>21.76 ± 0.19</td>
<td>4.8 ± 1.11</td>
</tr>
<tr>
<td>QSP 2.5 %</td>
<td>75.86 ± 0.03</td>
<td>45.61 ± 0.24</td>
<td>18.68 ± 0.37</td>
<td>3.4 ± 0.91</td>
</tr>
<tr>
<td>QSP 5 %</td>
<td>84.75 ± 0.06</td>
<td>56.09 ± 0.25</td>
<td>21.05 ± 0.20</td>
<td>2.8 ± 0.86</td>
</tr>
</tbody>
</table>
From the obtained results (Table 5), it could be noticed that the cooking yield percentage of beef burger samples containing quinoa seeds powder at levels of 2.5, 5, 7.5, and 10% was significantly higher (P<0.05) than the control sample. The cooking yield increased with increasing the level of quinoa seeds powder incorporated into beef burger from 2.5 to 10%. Also, From the same results (Table 5), it could be showed that moisture retention and fat retention values of beef burger samples increased with incorporate quinoa seeds powder into the beef burger. Higher moisture and fat retention of quinoa seeds powder may be attributed to its binding and stabilizing effect, these results are similar to those obtained by Özer and Seçen, (2018). The results of present study showed that utilization of quinoa seeds powder increased the yield of low-fat beef burger by decreasing cooking loss. It also helped to maintain the meat product dimension and juiciness. Low-fat beef burgers with no additives had higher cooking loss which led to a small, dry, and elastic burger.

From the obtained results (Table 5), it could be noticed that the replacing of meat with quinoa seeds powder could be also observed that the water holding capacity (WHC) of beef burger samples significantly increased by replacing meat with quinoa seeds powder. On the other hand, the incorporation of quinoa seeds powder into beef burgers caused a significant (p ≤ 0.05) increase in water holding capacity (WHC) value. Whereas, the increasing rate in the WHC of burgers increased with increasing the added ratio from quinoa seeds powder due to higher water absorption ratio of quinoa seeds powder as reported by (Stahnke, 1995).

**Color measurements of beef burgers containing quinoa seeds powder**

Quinoa seeds powder was shown a similar effect on color values (L*, a*, b*) in raw and cooked burger (Table 6). The use of quinoa seeds powder in raw and cooked beef burger resulted in increased L* and b* values and decreased a* values at all levels (P<0.05). Our results were agreement with some previous studies about the use of some flour in meat products and researchers have
indicated that responsible of color differences in meat products used different flour has the dilution of meat pigments rather than the color of the flour additives (Alakali, et al., 2010); (Ergezer, et al., 2014) (Shahiri et al., 2014).

Table (6): Color parameters of raw and cooked beef burger formulated with of quinoa seeds powder

<table>
<thead>
<tr>
<th>Sample</th>
<th>Raw beef burger</th>
<th>Cooked beef burger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>a*</td>
</tr>
<tr>
<td>Control</td>
<td>35.6c ± 0.01</td>
<td>8.25a ± 0.01</td>
</tr>
<tr>
<td>QSP 2.5 %</td>
<td>38.53d ± 0.01</td>
<td>8.01b ± 0.01</td>
</tr>
<tr>
<td>QSP 5 %</td>
<td>42.51c ± 0.01</td>
<td>7.71c ± 0.01</td>
</tr>
<tr>
<td>QSP 7.5 %</td>
<td>44.31b ± 0.01</td>
<td>7.51d ± 0.01</td>
</tr>
<tr>
<td>QSP 10 %</td>
<td>47.15a ± 0.01</td>
<td>6.58c ± 0.01</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD. values in the same column followed by the different letter superscripts are significantly different at $P \leq 0.05$.

**Texture analysis of cooked beef burger containing quinoa seeds powder**

As presented in Table (7), beef burgers containing QSP showed higher hardness than control at different levels (2.5, 5.0, 7.5, and 10%) ($p < 0.05$); so, the incorporation of QSP with meat protein resulted in increased firmness. Similar to (Brewer, 2012), at first, water is hold by contractile proteins and, for this reason, a temperature increase or pH reduction can promotes a higher drip and cook losses. Cohesiveness was lower in the treatments in which the QSP were used when compared to control at different levels (2.5, 5.0, 7.5, and 10%) ($p < 0.05$). According to (Kassama, et al., 2003), proteins used as extenders increase the water hold ability and improve texture properties, as juiciness. However, in this work, there is a tendency for the structure to maintain cohesiveness when QSP added. Springiness was higher ($p < 0.05$) in control than in treatments with QSP, showing the influence of QSP on this characteristic of the product, so QSP helped to decrease springiness. Chewiness showed no difference among the treatments ($p < 0.05$). Similar values for hardness, cohesiveness and
springiness were found by (Aleson-Carbonell et al., 2005) in their study about beef burgers with added lemon albedo and by (Ramadhan, et al., 2012) when they studied duck meat burgers.

Table (7): Texture analysis of cooked beef burger formulated with of quinoa seeds powder

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Firmness</th>
<th>Cohesiveness</th>
<th>Gumminess</th>
<th>Chewiness</th>
<th>Springiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>27.32 ± 0.03</td>
<td>0.91 ± 0.01</td>
<td>24.61 ± 0.02</td>
<td>22.07 ± 0.02</td>
<td>0.85 ± 0.01</td>
</tr>
<tr>
<td>QSP 2.5 %</td>
<td>30.19 ± 0.04</td>
<td>0.85 ± 0.01</td>
<td>22.67 ± 0.01</td>
<td>21.23 ± 0.09</td>
<td>0.65 ± 0.01</td>
</tr>
<tr>
<td>QSP 5 %</td>
<td>33.22 ± 0.05</td>
<td>0.65 ± 0.01</td>
<td>20.46 ± 0.02</td>
<td>23.65 ± 0.01</td>
<td>0.57 ± 0.01</td>
</tr>
<tr>
<td>QSP 7.5 %</td>
<td>35.91 ± 0.03</td>
<td>0.44 ± 0.01</td>
<td>18.12 ± 0.02</td>
<td>22.67 ± 0.01</td>
<td>0.34 ± 0.01</td>
</tr>
<tr>
<td>QSP 10 %</td>
<td>37.8 ± 0.04</td>
<td>0.33 ± 0.01</td>
<td>16.34 ± 0.01</td>
<td>21.58 ± 0.01</td>
<td>0.3 ± 0.01</td>
</tr>
</tbody>
</table>

Sensory evaluation of beef burger formulated with of quinoa seeds powder

Sensory evaluations of fortified beef burger with four different levels of quinoa seeds powder (2.5; 5; 7.5 and 10%) are presented in Table (8). The results showed no significant differences (P < 0.05) between the tested fortified burger at all levels of quinoa seeds powder, when compared to the control sample regarding taste; color and overall acceptability. Fortified burger with 7.5 and 10% quinoa seeds powder had lower scores for odor (8.78 ± 0.01 and 8.50 ± 0.01, respectively), texture (8.61 ± 0.01 and 8.32 ± 0.01, respectively) and appearance (8.75 ± 0.01 and 8.58 ± 0.01, respectively) which significantly differed at (P < 0.05) compared to the control burger scores (9.13 ± 0.01; 9.81 ± 0.01 and 9.37 ± 0.01, respectively). These findings align with previous research claims made by (Bahmanyar et al., 2021). Sindhuja, et al., (2005) revealed that quinoa seeds could be used as carriers of nutrition, resulting in an improved diet, and can be utilized as a functional food ingredient. QSP can be added to wheat flour with various recipes in the baking, including breads, cookies, muffins, pancakes, pasta, muffins, and puddings (Schoenlechner et al., 2010). Finally, in the present study, substitute of fat with QSP could not affect color, taste, and overall acceptability of sensory attributes with agreement with (Bahmanyar et al., 2021) who investigated the physicochemical, nutritional and sensorial characteristics of beef burgers formulated with QSP. It could improve overall acceptability and taste of sensory attributes.
Table (8): Sensory evaluation of beef burger prepared with different levels of quinoa seeds powder

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Color</th>
<th>Odor</th>
<th>Texture</th>
<th>Taste</th>
<th>Appearance</th>
<th>overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>19.00 ± 1.00</td>
<td>19.13 ± 0.01</td>
<td>19.81 ± 0.01</td>
<td>19.00 ± 1.00</td>
<td>19.37 ± 0.01</td>
<td>63.82 ± 1.74</td>
</tr>
<tr>
<td>QSP 2.5 %</td>
<td>19.00 ± 1.00</td>
<td>18.76 ± 0.01</td>
<td>18.78 ± 0.01</td>
<td>18.77 ± 0.01</td>
<td>18.88 ± 0.01</td>
<td>62.05 ± 0.99</td>
</tr>
<tr>
<td>QSP 5 %</td>
<td>18.80 ± 0.10</td>
<td>18.89 ± 0.01</td>
<td>18.8 ± 0.10</td>
<td>18.41 ± 0.01</td>
<td>18.88 ± 0.01</td>
<td>61.28 ± 0.09</td>
</tr>
<tr>
<td>QSP 7.5 %</td>
<td>18.83 ± 0.01</td>
<td>18.78 ± 0.01</td>
<td>18.61 ± 0.01</td>
<td>18.50 ± 0.01</td>
<td>18.75 ± 0.01</td>
<td>61.14 ± 0.04</td>
</tr>
<tr>
<td>QSP 10 %</td>
<td>18.73 ± 0.21</td>
<td>18.50 ± 0.01</td>
<td>18.32 ± 0.01</td>
<td>18.98 ± 0.01</td>
<td>18.58 ± 0.01</td>
<td>61.51 ± 0.26</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD. values in the same column followed by the different letter superscripts are significantly different at P≤0.05.

Effect of experimental diet on body weight gain and feed efficiency ratio in rats

The mean values of body weight gain (BWG) were calculated by the difference between initial and final weight for all rats in the study. The feed intake (g/day for each rat) and feed efficiency ratio (FER) were calculated for subjects in the negative control group, positive control group (hyperlipidemia), hyperlipidemia group fed additional QSP at 2.5, 5, 7.5 and 10% as summarized in Table (9).

Table (9): Effect of experimental diets on body weight, feed intake and feed efficiency ratio in rats fed on high fat diets

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Initial body weight (g)</th>
<th>Final body weight (g)</th>
<th>Body weight gain (g/day)</th>
<th>Daily feed intake (g/day)</th>
<th>Feed Efficiency Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 (Control)</td>
<td>114.5 ± 0.5</td>
<td>230d ± 2.65</td>
<td>3.3 ± 0.06</td>
<td>15.7 ± 0.26</td>
<td>0.21 ± 0.0</td>
</tr>
<tr>
<td>G2 (High fat diet)</td>
<td>114.5 ± 0.85</td>
<td>329c ± 10.15</td>
<td>6.13 ± 0.27</td>
<td>15.33b ± 0.45</td>
<td>0.41 ± 0.02</td>
</tr>
<tr>
<td>G3 (2.5 %)</td>
<td>114.83 ± 0.29</td>
<td>283a ± 3.61</td>
<td>4.8 ± 0.1</td>
<td>14.43c ± 0.32</td>
<td>0.33b ± 0.0</td>
</tr>
<tr>
<td>G4 (5 %)</td>
<td>115.17 ± 0.47</td>
<td>251.67b ± 2.08</td>
<td>3.87 ± 0.05</td>
<td>14.23d ± 0.15</td>
<td>0.27c ± 0.01</td>
</tr>
<tr>
<td>G5 (7.5 %)</td>
<td>115.03 ± 0.25</td>
<td>242.33c ± 1.53</td>
<td>3.64 ± 0.05</td>
<td>13.43f ± 0.15</td>
<td>0.27c ± 0.0</td>
</tr>
</tbody>
</table>
It is observed that there were significant increases in BWG, and FER for the control positive group (6.13 ± 0.27, & 0.4 ± 0.02) as compared to the healthy control group (negative; 3.3 ± 0.06, & 0.21 ± 0.01, respectively). However, the rats with induced hyperlipidemia received diet containing QSP at different levels, had significantly lower values (P< 0.05) for their BWG, FI and FER when compared to the positive control group. This indicates that QSP provided some protection against weight gain, when incorporated into the diet. These findings are in harmony, with those of (Barakat and Mahmoud, 2011), whose studies showed that a hyperlipidemia diet causes increase in BWG as compared with the BW and dietary content of a healthy control group. Also, consumption of QSP plays a role in regulating energy and maintains body weight balance. Moreover, Vega-Gálvez et al., (2010) indicated that quinoa is an important instance of functional food, used to improve nutrient intakes and lower body weight, and possibly reducing the risk of various cholesterol related diseases.

Effect of different levels of quinoa seeds powder on lipid profile of hyperlipidemia rats:

Figure (1) shows that the effect of experimental diets on plasma lipid profiles in rats fed on high fat diets. It is noted that the mean values of TC, TG, and LDL-C for the positive control group, increased (5.38±0.45, 0.88±0.012, 0.63 ±0.01 and 2.41 ±0.02 mmol/L), compared with the control negative group, (2.58 ± 0.02, 0.47 ± 0.007, 0.79 ± 0.02 and 1.64 ± 0.01 mmol/L, respectively). On the contrary, the mean value of HDL-C for the positive control group decreased compared with the control negative group. Which facilitates catabolism, by helping to transport excess cholesterol out of the peripheral tissue into the liver (Makni et al., 2008).
(TC), total cholesterol (TG) total triglycerides, (LDL-C) low density lipoprotein (HDL-C) High density lipoprotein

**Fig (1): Effect of experimental diets on plasma lipid profiles in rats fed on high fat diets**

Furthermore, our results closely correspond to those of *(Wang et al., 2012)* which indicated that the increase in HDL-C ratio is one of the most significant identifiers for any anti-hypercholesterolemia agent *(Lin et al., 2019)*. Rats which were fed a high-fat diet with four various levels from QSP fortified at 2.5, 5, 7.5 & 10%, had lower mean values of lipid profile compared with the positive control group. This might be as a direct result of reduced absorption of cholesterol, when accompanied by an increase in fecal bile acid and excretion of cholesterol, which is attributed to the dietary supplementation. In fact, the best results in lipid fractions for all treated groups was noticed in the group fed on a high fat diet fortified with QSP at 10%, because this treatment improved levels of serum cholesterol and triglycerides. These findings closely correspond to the previous researches of *(Farinazzi-Machado et al., 2012)* and *(Zevallos et al., 2014)*.

**Effect of different levels of quinoa seeds powder on kidney and liver function of experimental rat.**

The onset of renal diseases, or decreased kidney function, is marked by an increase in the concentrations of the metabolites in the blood. This may be due to increased activity rate of lipid peroxidation, as well as elevated triacylglycerol and cholesterol levels *(Gounden et al., 2020)*.
Results presented in Fig (2) summarize the analysis of the different ratios of QSP on serum creatinine, urea nitrogen; and uric acid in rats given a high fat diet, when compared to the negative control group.

**Fig (2). Effect of experimental diets on kidney and liver function of experimental rat**

High creatinine levels indicate that a person is experiencing kidney failure, and may occur as a result of increased cholesterol levels as revealed by (Barakat and Mahmoud, 2011). The current study’s findings, as shown in Fig (2) indicate that the level of serum creatinine in groups of rats given a high fat diet higher than the negative control groups (1.67 ± 0.06 vs 1.27 ± 0.06). The mean values and standard deviation of serum creatinine for those rats whose diet was fortified with 7.5% and 10% QSP were 1.13 ± 0.06 and 1.11 ± 0.06 mg/dl, respectively. These results indicated that there was an improvement in the serum creatinine level in groups fed on 10% QSP compared with the other groups of rats. The ingestion of a persistently high fat diet induced hyperlipidemia in rats, resulting in a higher value of serum urea nitrogen in the blood. The serum urea nitrogen reached 53.67 ± 0.06 in the positive control group, when compared with negative control group which had serum urea nitrogen levels of 35.5 ± 0.6 mg/dl. Thus, the increased levels may be related to the high fat diet, and
the kidneys’ loss of function. It is therefore concluded that when the body is using large amounts of fat in the diet, the serum urea nitrogen level will rise. The current results also indicated that the level of urea nitrogen at the conclusion of the experimental stage gradually decreased based on the levels of QSP fed to the rats. Results from the current study closely correspond with another study which demonstrated that renal damage in hyperlipidemia may be related to increase in serum urea nitrogen level which indicates dysfunction of the kidney at the tubular levels (Zevallos et al., 2014). It is observed that the control positive group, that was fed a high fat diet, has a statistically significant growth (p< 0.05) of serum uric acid levels when compared to those individuals in the control negative group fed the basal diet (6.57 ± 0.06 vs 4.47 ± 0.06 mg/dl). It was also observed that administration of 7.5% and 10% QSP significantly reduced the uric acid level were 5.03 ± 0.06 and 4.87 ± 0.06 mg/dl, respectively. Data revealed that a highly significant reduction of all parameters including urea, creatinine, nitrogen, and uric acid were observed in the group fed a high fat diet fortified with QSP at 10%. This indicates that dietary management is an essential component of care for patients with hyperlipidemia. This was previously determined by the research of (Zevallos et al., 2014). The results of the analysis of the influence of QSP on the liver enzyme in rats is displayed in Fig (2). Findings indicated that feeding rats on the basal diet containing 10% lard resulted in a statistically significant increase (P< 0.05) in serum AST and ALT when compared to healthy rats’ group (52.2 ± 0.1 and 59.67 ± 0.1 vs. 21.5 ± 0.1 and 28.2 ± 0.1 mg/dl , respectively). The high levels of AST and ALT in serum are indicators of liver dysfunction. These findings align with those of (Al-Dosari, 2011), which revealed that rats feeding on a high cholesterol diet for 70 day demonstrated a statistically significant effect and increased the bilirubin levels and serum liver marker enzymes. Results also indicated that, feeding a high fat diet, fortified with QSP at 5 and 7.5% and 10% levels, resulted in a statistically significant reduction (p<0.05) in serum AST and ALT when compared with those of the positive control group. The best results of liver function recorded was among hypercholesterolemia rats fed on a diet fortified with 10% QSP (Al-Dosari, 2011).

4-Conclusion

This research highlighted the properties of new meat products contained quinoa seeds powder as high-quality plant protein. From the data, it could be noticed that the quinoa seeds powder is a
good source of total phenolic content and had a great free radical scavenging activity. QSP replacement was found to be effective in improving the cooking yield, moisture and fat retention in meat burgers. QSP replacement up to 10% in meat burgers from original animal fat can be a suitable choice since it positively affects overall acceptability and flavor of meat burgers. The supplementation QSP that is rich in fiber and phenolic compounds seemingly suppressed the body weight gain, and it remarkably lowered plasma lipid concentrations and improve liver and kidney functions in rats fed a high-fat diet. Efficacy test of lipid lowering action of QSP, suggest that this QSP burger would be beneficial for regulation of lipid metabolism or prevention of hyperlipidemia in experimental animal rats. According to these results, QSP addition can be used successfully as a fat replacer in ground meat products, to give good quality product and could be used as a functional food for hypolipidemic agent.

5-References


Stahnke, L. H., 1995. Dried sausage fermented with Staphylococcus xylosus at different ingredient


تحضير بيف بيرجر دعوم بمسحوق بذور الكينوا كغذاء صحي

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الملخص العربي

أجريت هذه الدراسة للتعرف على إمكانية تحضير بيرجر اللحم بإضافة مسحوق بذور الكينوا وتقدير خصائص جودته. لذلك، الهدف من هذه الدراسة هو تقييم تأثير إضافة مسحوق بذور الكينوا في تحضير خصائص جودة ببرجر اللحم البقري. تم تقسيم تأثير إضافة مسحوق بذور الكينوا بنسبة (2.5، 5، 7.5 و 10٪) على التركيب الكيميائي، صفات الطبخ، اللون، الرطوبة، والتحقيقي الحسي للبرجر المطهي. كذلك، تأثير إضافة مسحوق بذور الكينوا السابق على نسب دقيق الكينوا في تحسين خصائص طعام الفئران. كما أدى استخدام دقيق الكينوا في ببرجر اللحم البقري إلى الأفكار لزيادة قيمة L* و b* وانخفاض قيمة a* على جميع المستويات (P<0.05). أظهر تحليل القوام أنه مع إضافة دقيق الكينوا، تزداد قيمة صلابة البرجر، وتقل قيمة الالتصاق. أظهرت النتائج أيضا عدم وجود فروق ذات دلالة معنوية (P>0.05) بين البرجر المعالج دقيق الكينوا وبرجر البقري. وفقاً للنتائج، أظهرت الدقيقتين أيضاً عدم وجود فروق ذات دلالة معنوية (P<0.05) بين البرجر المعالج دقيق الكينوا وبرجر البقري.

ومن النتائج التي تم الحصول عليها، كانت مجموعة الفئران التي تم تغذيتها على نظام غذائي عالي الدهون معدلة بشكل كبير لخطر الإصابة بارتفاع دهون الدم. ومع ذلك، أشارت النتائج إلى أن النظام الغذائي المدعم بمستويات مختلفة من دقيق الكينوا الأدي إلى تقليل نسبة الدهون بالدم، وتحسين وظائف الكبد والكلي للفئران المصابين بارتفاع دهون الدم، عند مقارنتها بالمجموعة الضابطة الإيجابية. وبشكل أكثر تحديدًا، أدى اتباع نظام غذائي يحتوي على 10٪ من دقيق الكينوا إلى تقليل التأثير الضار لارتفاع دهون الدم. لذلك، قد تكون إضافة دقيق الكنوة لبرجر اللحم البقري خيارًا قابلاً للتطبيق في تحسين الخصائص الغذائية والتكنولوجية والحسية.

الكلمات الافتتاحية:

مسحوق بذور الكينوا، ببرجر اللحم، مضادات الأكسدة، الألياف الغذائية، غذاء وظيفي.
Received: April 2021
Accepted: June 2021