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physicochemical and biological evaluation of beef burger partially substituted with powdered quinoa seed instead of animal fat

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Abstract

The present study was conducted to identify the possibility of preparing meat beef burgers by substitution of animal fats by powdered quinoa seeds and its quality characteristics. Therefore, the aim of this study was to assess the effects of powdered quinoa seeds (PQS) in improving the quality characteristics of raw and cooked beef burgers. The effects of powdered quinoa seeds substitution (2.5, 5, 7.5, and 10%) on physicochemical properties, cooking quality, colour, texture, and sensory evaluation of cooked beef burgers for animals were evaluated. Furthermore, via a biological study, the impact of dietary supplementation with powdered quinoa seeds (PQS) 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 PQS into the beef burger. The use of PQS 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, the hardness values of beef burgers increased, and adhesiveness values decreased. Regarding to the taste; flavour; colour, and overall acceptability sensory evaluation showed, no significant value of evaluation level of powdered quinoa seeds differences ($P < 0.05$), among the tested substitution level of PQS, in relative to the control. 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 substitution 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% PQS reduced the adverse effect of hyperlipidemia. Therefore, these new beef burger formulas might be available option for the improvement of nutritional, technological, and sensory properties.

Use no more than 200 words.

Keywords : Powdered Quinoa Seeds, Beef burger, Antioxidant, Dietary Fibre, Functional food

Provide a maximum of 8 keywords.

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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 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 **(Paśko *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**).

Substitution of food products with quinoa is one of the methods for developing functional foods, as powdered quinoa seeds has been used in the manufacture of various foods such as bread, baby food, chips, and beer, but studies on the use of powdered quinoa seeds 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 **WHO (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. Powdered quinoa seeds is used as a substitute for both soya protein and bread crumbs in the traditional burger formula (**Pellegrini *et al.*, 2018**). Therefore, the present study aims to evaluate the physical,

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chemical, nutritional, and sensory properties of beef burgers that contain powdered quinoa seeds as a partial substitute for fat.

2. Materials and Methods

Materials

Quinoa (*Chenopodium quinoa Willd* L.) seeds were purchased from the grain Department Field Crops Research Institute, 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-Gomhoryia Company, Cairo**.**

Methods

Preparation of Quinoa seeds

Quinoa (*Chenopodium quinoa Willd* L.) Seeds were washed with distilled water (at 37 °C) in the ratio of 1:2 (powdered quinoa seeds: distilled water)) to remove dust and any strange material. This procedure was performed twice, and then the powdered quinoa seeds were soaked in distilled water for 12 hours. After soaking in distilled water, the powdered quinoa seeds were dried at 40 °C for 12 hours in a hot air oven. The dried powdered quinoa seeds were milled to obtain a powder by using a laboratory hammer mill (Retsch, Germany). The powdered quinoa seeds 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 powdered quinoa seeds. This mixture was left on the shaker for 24 hours, after that the mixture was centrifuged (3000 RBM for 15 min) and the supernatant was filtrated using whatman 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: DPPH radical-scavenging activity (%) = [(Ab control – Ab sample) / Ab control] * 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 minced with 15 % fat for 15 min as a control substitution level of

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powdered quinoa seeds ,i.e. 2.5-5-7.5and 10% tested of animal fats was followed,(Table 1) of 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 were 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 powdered quinoa seeds (Table 1).

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

Treatment	Levels of Powdered Quinoa seeds Components					
	Meat (%)	Onion (%)	Salt (%)	Beef burger Spices (%)	Animal Fat (%)	Powdered quinoa seeds (%)
G1	67	15.5	1.25	1.25	15	-
G3	67	15.5	1.25	1.25	12.5	2.5
G4	67	15.5	1.25	1.25	10	5
G5	67	15.5	1.25	1.25	7.5	7.5
G6	67	15.5	1.25	1.25	5	10

G 1 (Control Negative). **G3** 2.5% PQS, **G4** 5 % PQS, **G5** 7.5% PQS, **G6** 10 % PQS

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 beef 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**).

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

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

$$\text{Fat retention \%} = \frac{\text{Cooked weight X \% Fat in cooked}}{\text{Uncooked weight X \%Fat in uncooked}} \times 100$$

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.

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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 plan meter. The WHC was calculated as cm^2 /0.3g by subtracting the area of the internal zone from that of the outer.

Color Measurements

The color of cooked beef burger samples was measured at room temperature using a hand-held Chroma meter (model cR-400, Konica Minolta, Japan) and CIE-l-AB parameters (*L**, *a** and *b*) were determined. The results were expressed in terms of *L** (lightness), *a** (redness-greenness) article *b* (yellowness-blueness) according to the methods described by (**Mc Gurie., 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 Rahman**, *et al*., (2009).**

Sensory evaluation

Sensory evaluation was carried out by 25 staff members of Food Technology Research Institute Giza, Egypt. Fresh samples of burgers were cooked 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% powdered quinoa seeds beef 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 rats (110-130 g) 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 powdered quinoa seeds (negative control). The second group was fed

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on a high-fat diet (positive control). The third group to sixth groups were fed on the high-fat diet with different substitution of powdered quinoa seeds analyses 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 was conducted. 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 (%)

Groups	Corn starch	Casein	Corn Oil	Cellulose	Salt	Vit	Animal Fat	Powdered quinoa seeds	Choline
G 1	65	15	10	5	3.8	1	0	0	0.2
G 2	50	15	10	5	3.8	1	15	0	0.2
G 3	50	15	10	5	3.8	1	12.5	2.5	0.2
G 4	50	15	10	5	3.8	1	10	5	0.2
G 5	50	15	10	5	3.8	1	7.5	7.5	0.2
G 6	50	15	10	5	3.8	1	5	10	0.2

G 1 (Control Negative), **G2** (Control Positive high fat diet). **G3** 2.5% PQS**, G4** 5 % PQS, **G5** 7.5% PQS**, G6** 10 %PQS

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 Prencipel (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**)

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3-Results and Discussion

Chemical composition of powdered quinoa seeds

Table (3) shows the results of chemical composition, of powdered quinoa seeds (PQS). 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 powdered quinoa seeds 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 powdered quinoa seeds contain relatively fewer proteins compared to legumes (22.75-37.9%), as indicated (**Sohaimy *et al*. 2018)**. However, powdered quinoa seeds 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 powdered quinoa seeds (g/ 100g dry weight)

Chemical composition	Powdered Quinoa Seeds
Protein	15.22 ± 0.35
Fat	4.36 ± 0.17
Ash	3.4 ± 0.02
Moisture	12.8 ± 0.31
Crude fibre	7.66 ± 0.42
Total carbohydrates	56.56 ± 0.38

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, due to, 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 antioxidant 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

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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**). Powdered quinoa seeds 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 **(Paśko *et al.*, 2009).**

Table (4): Total phenolic, Flavonoid and antioxidants activity of powdered quinoa seeds

Analysis	Powdered quinoa seeds
phenolic mg/100g	18.4
Flavonoid mg/100g	14.9
DPPH %	22.73

Values are the means of three replicates

In the current study, the total phenolic content in powdered quinoa seeds 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 (**Scalbert *et al,* 2005)**. Flavonoids are organic compounds belong to polyphenols (flovonols, 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 powdered quinoa seeds 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 powdered quinoa seeds methanolic extracts activity against DPPH of quinoa seeds powder was 22.73%.

Cooking measurements of beef burgers containing powdered quinoa seeds

Beef burgers minced 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 beef 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. Substitute by PQS 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 beef burger lead to change the cooking measurements due to its ability to retain

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more moisture and fatty substance, which increases the yield of the beef burger. Also PQS containing a high percentage of protein that supports meat protein and reduces the effect of the minced process (K**ovácsné Oroszvári *et al.*, 2006)**. The obtained results are tabulated as in Table (5).

Table (5). Cooking Characteristics of beef burgers formulated with different levels of powdered quinoa seeds

Treatment	Cooking yield %	Moisture retention%	Fat retention%	Water-Holding Capacity cm2
F1	$65.54^{e} \pm 0.06$	$40.46^{e} \pm 0.69$	$21.76^{c} \pm 0.19$	$4.8^{a} \pm 1.11$
F2	$75.86^{d} \pm 0.03$	$45.61^{d} \pm 0.24$	$18.68^{e} \pm 0.37$	$3.4^{b} \pm 0.91$
F3	$84.75^{c} \pm 0.06$	$56.09^{c} \pm 0.25$	$21.05^{d} \pm 0.20$	$2.8^{c} \pm 0.86$
F4	$89.66^{b} \pm 0.05$	$63.54^{b} \pm 0.31$	$22.76^{b} \pm 0.21$	$1.9^{d} \pm 0.79$
F5	$93.61^{a} \pm 0.04$	$69.27^{a} \pm 0.35$	$23.06^{a} \pm 0.05$	$1.6^{e} \pm 0.74$

F 1 (Control Negative), **F2** 2.5% PQS, **F3** 5 % PQS, **F4** 7.5% PQS, **F5** 10 % PQS

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

From the obtained results (Table 5), it could be noticed that the cooking yield percentage of beef burger samples containing powdered quinoa seeds 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 powdered quinoa seeds 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 powdered quinoa seeds into the beef burger. Higher moisture and fat retention of powdered quinoa seeds 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 powdered quinoa seeds 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 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 beef burger with powdered quinoa seeds could be also observed that the water holding capacity (WHC) of beef burger samples significantly increased by replacing meat with powdered quinoa seeds. On the other hand, the incorporation of powdered quinoa seeds into beef burgers caused a significant ($p \leq 0.05$) increase in water holding capacity (WHC) value. Whereas, the increasing rate in the WHC of beef burgers increased with increasing the added ratio from

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powdered quinoa seeds due to higher water absorption ratio of powdered quinoa seeds as reported by (**Stahnke., 1995**).

Color measurements of beef burgers containing powdered quinoa seeds

Powdered quinoa seeds was shown a similar effect on color values (L*, a*, b*) in raw and cooked beef burger (Table 6). The use of powdered quinoa seeds 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 beef burger 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 powdered quinoa seeds

Burger formula	Raw beef burger			Cooked beef burger		
	L	***a****	***b****	***L***	***a****	***b****
F1	$35.6^{e} \pm 0.01$	$8.25^{a} \pm 0.01$	$10.84^{e} \pm 0.01$	$32.15^{e} \pm 0.01$	$7.07^{a} \pm 0.11$	$12.71^{d} \pm 0.01$
F2	$38.53^{d} \pm 0.01$	$8.01^{b} \pm 0.01$	$11.93^{d} \pm 0.01$	$35.25^{d} \pm 0.01$	$6.95^{b} \pm 0.01$	$13.52^{c} \pm 0.01$
F3	$42.51^{c} \pm 0.01$	$7.71^{c} \pm 0.01$	$13.41^{c} \pm 0.01$	$38.89^{c} \pm 0.01$	$5.54^{c} \pm 0.02$	$16.35^{b} \pm 0.01$
F4	$44.31^{b} \pm 0.01$	$7.51^{d} \pm 0.01$	$14.15^{b} \pm 0.01$	$39.03^{b} \pm 0.01$	$5.41^{d} \pm 0.01$	$16.38^{b} \pm 0.01$
F5	$47.15^{a} \pm 0.01$	$6.58^{e} \pm 0.01$	$14.52^{a} \pm 0.01$	$42.50^{a} \pm 0.01$	$4.35^{e} \pm 0.01$	$17.10^{a} \pm 0.01$

F 1 (Control Negative) .**F2** 2.5% PQS, **F3** 5 % PQS, **F4** 7.5% PQS, **F5** 10 % PQS

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 powdered quinoa seeds

As presented in Table (7), beef burgers containing PQS showed higher hardness than control at different levels (2.5, 5.0, 7.5, and 10%) ($P < 0.05$); so, the incorporation of P QS 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 cooking losses. Cohesiveness was lower in the treatments in which the PQS 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 PQS added. Springiness was higher ($p < 0.05$) in control than in treatments with PQS, showing the influence of PQS on this characteristic of the product, so PQS helped to decrease springiness. Chewiness showed no difference among the treatments ($p < 0.05$). Similar values for hardness, cohesiveness and

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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 different levels of powdered quinoa seeds

Treatment	Firmness	Cohesiveness	Gumminess	Chewiness	Springiness
F1	$27.32^{e} \pm 0.03$	$0.91^{a} \pm 0.01$	$24.61^{a} \pm 0.02$	$22.07^{a} \pm 0.02$	$0.85^{a} \pm 0.01$
F2	$30.19^{d} \pm 0.04$	$0.85^{b} \pm 0.01$	$22.67^{b} \pm 0.01$	$21.23^{a} \pm 0.09$	$0.65^{b} \pm 0.01$
F3	$33.22^{c} \pm 0.05$	$0.65^{c} \pm 0.01$	$20.46^{c} \pm 0.02$	$23.65^{a} \pm 0.01$	$0.57^{c} \pm 0.01$
F4	$35.91^{b} \pm 0.03$	$0.44^{d} \pm 0.01$	$18.12^{d} \pm 0.02$	$22.67^{a} \pm 0.01$	$0.34^{d} \pm 0.01$
F5	$37.8^{a} \pm 0.04$	$0.33^{e} \pm 0.01$	$16.34^{e} \pm 0.01$	$21.58^{a} \pm 0.01$	$0.3^{e} \pm 0.01$

F 1 (Control Negative), **F2,** 2.5% PQS**, F3** 5 % PQS, **F4** 7.5% PQS**, F4** 10 % PQS

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

Sensory evaluation of beef burger formulated with of powdered quinoa seeds

Sensory evaluations of substitute 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 substitute beef burger at all levels of powdered quinoa seeds, when compared to the control sample regarding taste; color and overall acceptability. Substitute burger with 7.5 and 10% powdered quinoa seeds 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 beef 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 powdered quinoa seeds could be used as carriers of nutrition, resulting in an improved diet, and can be utilized as a functional food ingredient. PQS 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 PQS 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 PQS). It could improve overall acceptability and taste of sensory attributes.

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Table (8): Sensory evaluation of beef burger prepared with different levels of powdered quinoa seeds

Treatment	Color 20	Odor 20	Texture 20	Taste 20	Appearance 20	overall acceptability
F1	19.00 ^{a} ± 1.00	19.13 ^{a} ± 0.01	19.81 ^{a} ± 0.01	19 .00 ^{a} ± 1.00	19.37 ^{a} ± 0.01	63.82 ^{a} ± 1.74
F2	19.00 ^{a} ± 1.00	18.76 ^{b} ± 0.01	18.78 ^{b} ± 0.01	18.77 ^{a} ± 0.01	18.88 ^{b} ± 0.01	62.05 ^{ab} ± 0.99
F3	18.80 ^{a}± 0.10	18.89 ^{b} ± 0.01	18.8 ^{b} ± 0.10	18.41 ^{a} ± 0.01	18.88 ^{b} ± 0.01	61.28 ^{ab} ± 0.09
F4	18.83 ^{a} ± 0.01	18.78 ^{c} ± 0.01	18.61 ^{c} ± 0.01	18.50 ^{a} ± 0.01	18.75^{c} ± 0.01	61.14 ^{ab} ± 0.04
F5	18.73 ^{a} ± 0.21	18.50 ^{d} ± 0.01	18.32 ^{d} ± 0.01	18.98 ^{a} ± 0.01	18.58 ^{d} ± 0.01	61.51 ^{ab} ± 0.26

F 1 (Control Negative), . **F2** 2.5% PQS**, F3** 5 % PQS, **F4** 7.5% PQS**, F5** 10 % PQS
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 of 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 experimental animals in the negative control group, positive control group (hyperlipidemia), hyperlipidemia group fed additional PQS 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

Treatment	Initial body weight (g)	Final body weight (g)	Body weight gain (g/day)	Daily feed intake (g/day)	Feed Efficiency Ratio
F1	114.5 ^{a} ± 0.5	230^{d} ± 2.65	3.3 ^{e} ± 0.06	15.7 ^{a} ± 0.26	0.21 ^{e} ± 0.0
F2	114.5 ^{a} ± 0.85	329 ^{e} ± 10.15	6.13 ^{a} ± 0.27	15.33 ^{b}± 0.45	0.41 ^{a} ± 0.02
F3	114.83 ^{a} ± 0.29	283 ^{a}± 3.61	4.8 ^{b} ± 0.1	14.43 ^{c} ± 0.32	0.33 ^{b}± 0.0
F4	115.17 ^{a} ± 0.47	251.67 ^{b} ± 2.08	3.87 ^{c} ± 0.05	14.23 ^{d} ± 0.15	0.27 ^{c} ± 0.01
F5	115.03 ^{a} ± 0.25	242.33 ^{c} ± 1.53	3.64 ^{d} ± 0.05	13.43 ^{f} ± 0.15	0.27 ^{c} ± 0.0
F6	115.13 ^{a} ± 0.35	231.33 ^{d}± 1.15	3.27 ^{e} ± 0.03	13.9 ^{e} ± 0.2	0.24 ^{d} ± 0.01

G 1 (Control Negative) , **G2** (Control Positive High fat diet) . **G3** 2.5% PQS**, G4** 5 % PQS, **G5** 7.5% PQS**, G6** 10 % PQS
Data are expressed as mean ± SD. values in the same column followed by the different letter superscripts are significantly different at P≤0.05.

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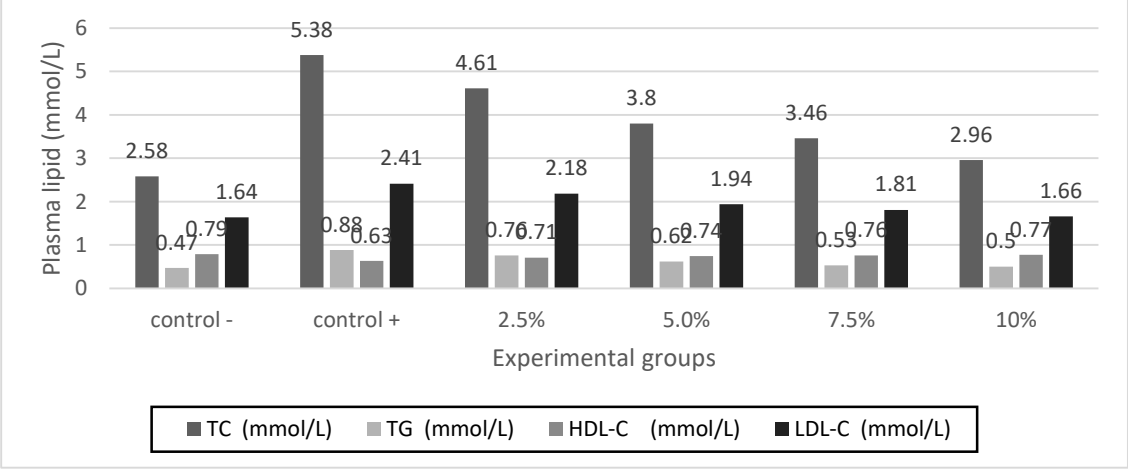
It is observed that there were significant increases in BWG, and FER for the control positive group (6.13 ± 0.27, & 0.4 ± 0.02) as compared to the healthy control group (negative; 3.3 ± 0.06, & 0.21 ± 0, respectively). However, the rats with induced hyperlipidemia received diet containing PQS at different levels, had significantly lower values (P< 0.05) for their BWG, FI and FER when compared to the positive control group. This indicates that PQS provided some protection against weight gain, when incorporated into the diet. These findings are in harmony, with those of **Barakat and Mahmoud, (2011**), who reported that a hyperlipidemia diet causes increase in BWG as compared with the BW and dietary content of a healthy control group. Also, consumption of PQS plays a role in regulating energy and maintains body weight balance. Moreover, **Vega-Gálvez *et al.*, (2010**) indicated that powdered quinoa seeds 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 powdered quinoa seeds 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).**

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



(TC), total cholesterol (TG) total triglycerides, (LDL-C) low density lipoprotein (HDL-C) High density lipoprotein

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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 PQS substitution 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 substitution 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 powdered quinoa seeds on kidney and liver function of experimental rat.

Results presented in Fig (2) summarize the serum analysis resulted from of the different ratios of PQS on serum creatinine, urea nitrogen; and uric acid in rats given a high fat diet, when compared to the negative control group. The current study's findings, in the same fig. 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 substitution with 7.5% and 10% PQS 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% PQS 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 PQS 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% PQS significantly reduced the uric acid level from 5.03 ± 0.06 to 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 substitution with PQS at 10%. This indicates that

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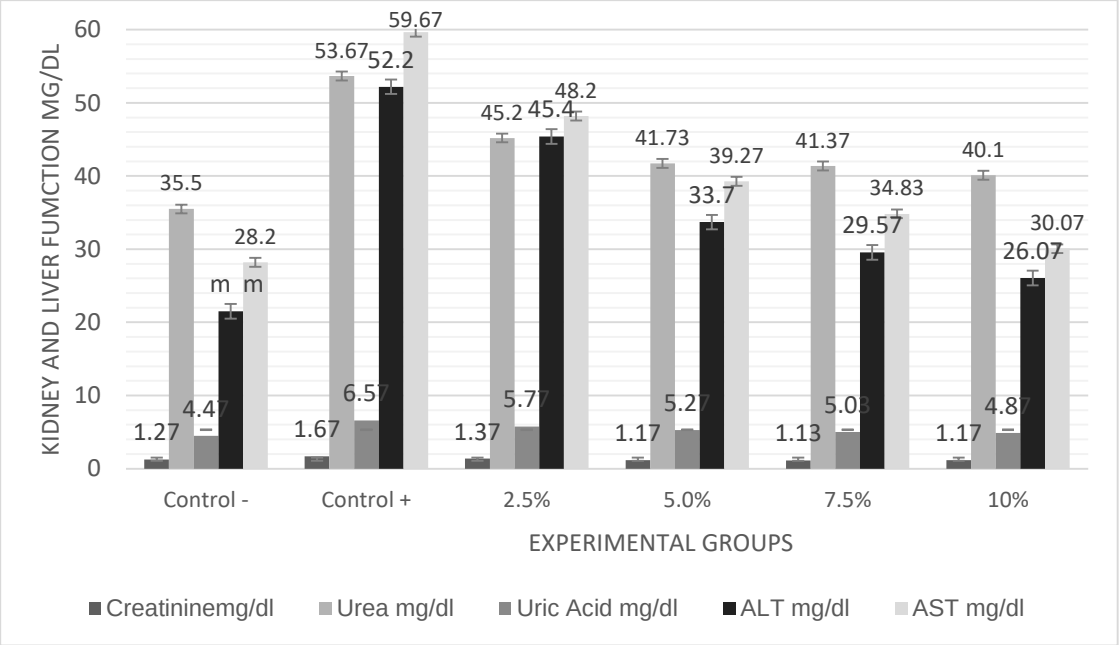
dietary management is an essential component of care for patients with hyperlipidemia. The onset of renal diseases, or decreased kidney function, is marked by an increase in the concentrations of the metabolites in the blood. This may be due to increased activity rate of lipid peroxidation, as well as elevated triacylglycerol and cholesterol levels **(Gounden *et al.*, 2020)**. 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**).

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



The results of rat liver enzymes as influenced by PQS is displayed in Fig (2). Findings indicated that feeding rats on the basal diet containing 10% high fat diet 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 substitution with PQS 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 substitution with 10% PQS **Al-Dosari,** (**2011**).

4.Conclusion

The present study highlighted the properties of new beef burger products contained powder quinoa seeds d as high-quality plant protein. From the data, it could be noticed that the powdered quinoa seeds is a good source of total phenolic content and had a great free radical scavenging activity. PQS replacement was found to be effective in improving the cooking yield, moisture and fat retention in meat burgers. PQS substitution up to 10% in beef burgers from original animal fat can be a suitable choice since it positively affects overall acceptability and flavor of beef burgers. The supplementation PQS 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 PQS, suggest that this PQS burger would be beneficial for regulation of lipid metabolism or prevention of hyperlipidemia in experimental animal rats. According to these results, PQS substitution can be used successfully as a fat replacer in ground beef burger products, to give good quality product and could be used as a functional food for hypolipidemic agent.

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التقييم الفيزيائي الكيميائي والبيولوجي لبرغر اللحم باستبدال جزء من الدهون بمطحون بذور الكينوا

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الملخص العربي

أجريت هذه الدراسة للتعرف على إمكانية تحضير برجر اللحم البقرى بإضافة مطحون بذور الكينوا وتقدير خصائص جودته. لذلك ، الهدف من هذه الدراسة هو تقييم تأثيرإستبدال مطحون بذورالكينوا في تحسين خصائص جودة برجر اللحم البقري. تم تقييم تأثيرإستبدال مطحون بذورالكينوا بنسب (2.5 ، 5 ، 7.5 و 10٪) على التركيب الكيميائي و الفيزيائي ، صفات الطبخ ، اللون ، الملمس ، والتقييم الحسي للبرجر المطهي. كذلك تأثير إستبدال نسب مطحون الكينوا السابقة على تغذية الفئران المصابة بارتفاع دهون الدم. تم تسجيل المتغيرات الغذائية متضمنة المتناول من الطعام ، زيادة الوزن ، ونسبة كفاءة التغذية. بالإضافة إلى ذلك ، . بالإضافة إلى ذلك ، تم قياس الكوليسترول الكلي ومشتقاته ، الدهون الثلاثية ، وظائف الكبد والكلى. وقد توصلت الدراسة الي تحسين خصائص الطهي والاحتفاظ بكل من الرطوبة والدهون نتيجة إستبدال مطحون الكينوا الي برجر اللحم البقري. كما أدى استخدام مطحون الكينوا في برجر اللحم البقري إلى زيادة قيم L^* و b^* وانخفاض قيم a^* على جميع المستويات ($P<0.05$). أظهر تحليل القوام أنه مع إستبدال مطحون الكينوا ، تزداد قيم صلابة البرجر، وتقل قيم الالتصاق. أظهرت النتائج ايضا عدم وجود فروق ذات دلالة معنوية ($P<0.05$) بين البرجر اللحم البقري المستبدل بمطحون الكينوا باختلاف نسب الاضافه ، بالمقارنة مع عينة الكنترول فيما يتعلق بالطعم والنكهة واللون والقبول العام. ومن النتائج التي تم الحصول عليها ، كانت مجموعة الفئران التي تم تغذيتها على نظام غذائي عالي الدهون معرضة بشكل كبير لخطر الإصابة بارتفاع دهون الدم. ومع ذلك ، أشارت النتائج إلى أن البرجرالمستبدل بمستويات مختلفة من مطحون الكينوا يؤدي الي تقليل نسب الدهون الدم ، وتحسين وظائف الكبد والكلى للفئران المصابة بارتفاع دهون الدم ، عند مقارنتها بالمجموعة الضابطة الإيجابية. وبشكل أكثر تحديدًا ، أدى اتباع نظام غذائي يحتوي على 10٪ من مطحون الكينوا إلى تقليل التأثير الضار لارتفاع دهون الدم. لذلك ، قد تكون اضافة مطحون الكينوا لبرجر اللحم البقري خيارًا قابلاً للتطبيق في تحسين الخصائص الغذائية والتكنولوجية والحسية كبرجر وظيفي جديد.

الكلمات الافتتاحية:

مطحون بذور الكينوا ، برجر اللحم ، مضادات الأكسدة ، الألياف الغذائية ، غذاء وظيفي

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