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Study on quality characteristics of camel burger and evaluating its stability during frozen storage

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Abstract This study investigated the influence of replacing One-humped camel meat instead of cow meat (0, 25, 50, 75 and 100 %) on quality characteristics and frozen storage stability in burgers. For this purpose thiobarbituric acid test (TBA-RS), cooking characteristics, color parameters, texture and sensory properties were studied during 3 months at −18 °C. Significant differences ($p < 0.05$) were observed in the moisture retention, diameter reduction, sensory properties, lightness, yellowness and springiness. Cooking yield, TBA-RS, fat retention, cohesiveness, flavor and texture showed significant differences ($p < 0.05$) through storage. Other evaluated properties of burgers showed no significant differences ($p > 0.05$) in various levels of camel meat and over storage term. Moisture retention of burgers increased with increasing of camel meat content. The sensory panel scores for flavor, texture, juiciness and overall acceptability increased but color scores decreased with increasing the level of camel meat. Cooking yield, fat retention and cohesiveness decreased by increasing the storage period.

Keywords Burger · Frozen storage · One-humped camel

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Introduction

Owing to the increasing human population and declining per capita production of food, there is a demanding need to develop marginal resources and optimize their utilization through appropriate livestock production systems [1].

Camels (especially dromedary) are one of the most fundamental pillars of the national economy and food security for many countries in the world [2]. The unique anatomical, physiological, and behavioral characteristics enable camels to reproduce and produce meat and milk under difficult circumstances such as drought, poor grazing, and low management. Furthermore, more recently, distinctive physiological characteristics and production capability of camels have described from time to time by several researches [3–5].

According to Tandon et al. [6], the camel is likely to produce animal protein at a comparatively low cost in the arid zones based on feeds and fodder that are generally not utilized by other domestic species due to either their size or food habits.

One-hump camel (*Camelus dromedarius*) belongs to genus Camelus which, together with the genera Lama and Vicugna, belong to the family Camelidae [7].

As reported by FAO [8], there are approximately 25.3 million camels in the world, of which 21.5 million are found in Africa and 3.8 million in Asia. In fact, 22.5 million are believed to be one-humped camels and 2.8 million two-humped.

From the chemical standpoint camel meat contains more moisture than beef [9]. It was noted that the camel had a slightly higher ratio of moisture to protein than beef or lamb [10]. Babiker and Tibin [9] found that, in comparison to beef, the protein content and intramuscular fat of camel meat is significantly greater and lower, respectively. In addition, camel meat has notably lower sarcoplasmic protein than beef. Therefore, camel meat can be an appropriate alternative to diminish animal protein shortage.

The nutritional value of camel meat is similar to other red meats, even though the low amount of fat [10] and cholesterol [11] content have caused camel meat considered as a healthy option. Moreover, lower concentrations of organochlorine pesticides in Egyptian camel meat have been reported in comparison to beef and sheep meats [12]. However, there is a negative perception in public that camel meat is tougher and of lower quality than beef that makes the camel meat consumption to be restricted to the people of specific area [13]. If camel meat converts into processed meat products such as burgers and sausages, it might be more acceptable to domestic consumers [14].

To the best of our knowledge, there is a relative lack of research regarding the use of camel meat in burgers. The aim of this work was evaluating the effect of camel meat replacement in beef burger formulation on nutritional, cooking and sensory quality of burgers and also its stability during 90 days storage at −18 °C.

Materials and methods

Camel and beef meat were purchased from local market. All meats were ground, wrapped and maintained in freezer at −18 °C until be used.

Burger manufacture

Five formulations of burger were obtained, varying in the level of camel meat used. Burgers were prepared according to the industrial formula: 75 % (w/w) meat (20 % fat), 12.5 % (w/w) flour, 10 % (w/w) onion, 1.1 % (w/w) sodium chloride and 1.4 % (w/w) spices (black pepper, red pepper, nutmeg, thyme, cinnamon, garlic powder). Five levels of camel meat treatments 0 % (beef only), 25, 50, 75, 100 % (camel only) were used and each treatment was prepared in three replicates independently.

After thawing overnight in refrigerator (±4 °C), meat was ground through a 5-mm plate in a grinder (Kenwood, Spain). Meat sample was used for proximate analysis as described by AOAC [15]. Then the rest of the meat and the other ingredients were thoroughly mixed to obtain a homogenous mixture. This mixture was shaped by using manual hamburger patty forming machine (9 cm internal diameter) to obtain patties of approximately 70 g and 1 cm thickness. Finally, the burgers were placed in plastic containers and held under frozen condition (−18 °C) until analysis in designated times. Sampling from each formula took place once every 2 weeks during 3 months storage.

Burger analysis

Chemical and physical analysis

Moisture, ash, protein and fat contents were specified by AOAC methods [16]. Moisture (g water/100 g sample) was determined by drying a 3 g sample at 100 °C to constant weight. Ashing was carried out at 500 °C for 5 h (g ash/100 g sample). Protein (g protein/100 g sample) was analyzed according to the Kjeldahl method. Factor 6.25 was used for conversion of nitrogen to crude protein. Fat (g fat/100 g sample) was determined by weight loss after a 6-cycle extraction with petroleum ether in a Sohxlet apparatus. Moreover, pH determinations were made using pH meter (Testo 230, Germany).

Lipid oxidation (thiobarbituric acid test)

Oxidative stability of cooked burger patties was evaluated by measuring the formation of thiobarbituric acid-reactive substances (TBA-RS) as described by Tarladgis et al. [17] with slight modification. Trichloroacetic acid was used instead of perchloric acid as recommended by Salih et al. [18]. Briefly, 10 g of each burger patty was dispensed in a cone plastic tube and homogenized with 35 ml of 4 % perchloric acid, using Ultra Turrax (IKA, T25, Germany) homogenizer (13,700 rpm for 1 min). The homogenate was centrifuged at 2500 × g for 3 min and filtered through Whatman No.40 filter paper. The filtrate was adjusted to 50 ml with perchloric acid (4 %). A 2 ml aliquot of the filtrate was transferred into a screw-capped test tube and mixed with 2 ml of 0.02 M TBA in perchloric acid (4 %). The mixture was vigorously agitated in a vortex and was heated in a boiling water bath (100 °C) for 45 min to develop the pink color. After cooling the reaction mixture under running water and centrifuging (2500 × g for 2 min), the absorbance was determined at 532 nm using a spectrophotometer (Biochrom, WPA Lightwave S2000, UK) against a blank that contained all the reagents, but no meat. The results were expressed as mg malondialdehyde (MDA)/kg burger patty, using a standard curve. Tetraethoxypropane was used as an MDA precursor in the standard curve.

Cooking characteristics

Thickness and diameter of each burger were measured at room temperature. Thereafter, burgers were cooked at 140 °C by contact grilling on a preheated electric grill (Delonghi, Italy) to achieve an internal end-point temperature of 72 °C. Thickness and diameter of cooked samples were measured once more. Diameter reduction and thickness increase were calculated on the following equations:

$$\%\text{Diameter reduction} = \left(\frac{\text{raw diameter} - \text{cooked diameter}}{\text{raw diameter}}\right) \times 100 \quad (1)$$

$$\%\ \text{Thickness increase} = \left(\frac{\text{cooked thickness} - \text{raw thickness}}{\text{raw thickness}}\right) \times 100 \quad (2)$$

The following calculations were performed to estimate the amount of fat and moisture retained in the samples, the cooking yield and shrinkage:

$$\%\ Fat\ \text{retention} = \frac{(\text{cooked weight} \times \%\ \text{fat in cooked burger})}{\text{raw weight} \times \%\ \text{fat in raw burger}} \times 100 \quad (3)$$

$$\%\ \text{Moisture retention} = \frac{(\text{cooked weight} \times \%\ \text{moisture in cooked burger})}{\text{raw weight} \times \%\ \text{moisture in raw burger}} \times 100 \quad (4)$$

$$\%\ \text{Cooking yeild} = \frac{\text{cooked weight}}{\text{raw weight}} \times 100 \quad (5)$$

$$\%\ \text{Shrinkage} = \frac{(\text{raw thickness} - \text{cooked thickness}) + (\text{raw diameter} - \text{cooked diameter})}{\text{raw thickness} + \text{raw diameter}} \times 100 \quad (6)$$

Color determinations

Color was measured on the surface of raw and cooked burgers using a chromameter (Konica Minolta, CR-410, Japan) equipped with a light source Illuminant *C* (2° observer). The chromameter was standardized with a white tile ($L^* = 98.14$, $a^* = -0.23$ and $b^* = 1.89$). Color was described by coordinates: lightness (L^*, ±white–black), redness (a^*, ±red–green) and yellowness (b^*, ±yellow–blue).

Texture analysis

Texture profile analysis (TPA) was performed on cooked samples at 4 ± 1 °C with a texture analyzer (Brookfield, QTS-25, USA) following AMSA procedures [19]. Cubic samples (1 × 1×1 cm) were cut from patties and subjected to a two-cycle compression test. Samples were compressed to 70 % of their original height with a cylindrical probe of 3.5 cm diameter at a compression load of 25 kg, and a cross-head speed of 20 cm/min. Texture profile parameters were determined following descriptions by Bourne [20] and interpreted as follows. *Hardness* (kg) is the maximum force required to compress the sample; *cohesiveness* is the extent to which sample could be deformed prior to rupture (A2/A1), A1 and A2 are the total energy required for the first and second compression, respectively; *springiness* (cm) is the ability of sample to recover its original shape after the deforming force is removed; *gumminess* (kg) is the force to disintegrate a semi-solid meat sample for swallowing (hardness × cohesiveness) and *chewiness* (kg × cm) is the work needed to masticate sample for swallowing (springiness × gumminess).

Sensory evaluation

Each formulation was cooked for sensory evaluation as previously described. Sensory analysis was performed by 30 trained panelists. Each panelist evaluated three replicates of all formulas; the sample was presented randomly to each panelist. Tap water was provided between samples to cleanse the palate. The evaluation included color, texture, flavor, juiciness and overall acceptability using a 7-point structured hedonic scale, in which the highest score of 7 expressed strong preference and 1 represented strong disfavor.

Statistical analysis

Data were analyzed as a completely randomized design with a 7 × 5 factorial arrangement of treatments using analysis of variance. Treatments means were compared by Duncan's multiple range tests using SPSS 16.0 for Windows (IBM Inc., Chicago, USA).

Results and discussion

Proximate composition and pH values

The proximate composition and pH value of camel burgers formulated with different levels of camel meat have been given in Table 1. Increasing the level of camel meat

Table 1 Effect of camel meat replacement on chemical composition and pH of burgers

Camel meat (%)	0	25	50	75	100	S.E. mean
pH	5.77^{a}	5.86^{a}	5.79^{a}	5.8^{a}	5.82^{a}	0.01
Ash (%)	1.69^{a}	1.92^{a}	1.95^{a}	1.8^{a}	2.12^{a}	0.07
Protein (%)	13.54^{a}	13.82^{a}	14.85^{ab}	14.96^{ab}	16.47^{c}	0.4
Fat (%)	12.61^{a}	13.8^{a}	14.63^{a}	14.22^{a}	16.8^{a}	0.7
Moisuture (%)	63.34^{a}	64.17^{a}	64.13^{a}	62.95^{a}	62.33^{a}	0.4

$^{a–c}$ Different superscripts in the same row indicate significant differences ($p < 0.05$)

resulted in a non-significant ($p > 0.05$) decrease in moisture, while pH, fat, protein, and ash increased non-significantly as well. Protein content of 100 % level was notably higher than 25 % level ($p < 0.05$). Kadim et al. [14] reported that protein levels of camel meat are higher than those in meat of other farm animal species. Marsh [21] and Thomason [22] found that many factors including pre-slaughter handling, post mortem treatment and muscle physiology are the determining factors for ultimate pH value of meat. The slight increase in pH values of the burger with an increase of the level of camel meat may be due to those factors in camel meat. In addition, Kadim et al. [14] reported the ultimate pH value of camel meat was slightly higher than beef meat. These results agreed with those reported by FAO [23] and Guingnot et al. [24] who showed that the differences in pH level might be due to the changes occurred after slaughter owing largely to the differences in the amount of glycogen available for transformation into lactic acid.

Oxidative rancidity

No significant differences ($p > 0.05$) were found for TBA-RS values in various levels of camel meat and during storage time. TBA-RS values of the 50, 75 and 100 % levels of camel meat burger were higher than control and 25 %; moreover, TBA-RS values increased during the storage time and the highest value obtained for day 90 (1.73 mg/kg). Camel meat had the higher fat content which could accelerate lipid oxidation and it might be a reason for higher lipid oxidation of the burgers made with camel meat. These results were in line with those of López et al. [25] who reported the highest TBA-RS values in ostrich burgers with the highest fat content. Our finding contrast sharply with the information reported by Ibrahim and Nour [26] in which it was mentioned TBA-RS values decreased with increasing the level of camel meat.

Cooking properties

Cooking yield

There was insignificant increase in cooking yield with increasing the level of camel meat ($p > 0.05$). The lowest (68.2 %) and highest (79.9 %) cooking yield observed in control and 100 % levels of camel burger respectively. However, storage time affected ($p < 0.05$) the cooking yield remarkably. Burgers had the highest reduction in cooking yield in day 90; however, the samples in the other days showed similar cooking yield. Kadim et al. [14] indicated that camel's *longissimus* muscle had significantly lower cooking loss percent than beef muscle. In addition, our findings agree with those of Fthi-alrhman [27] who found that camel meat frankfurter had an improved cooking loss and water holing capacity when compared with beef sample. Elsharif [28] reported that cooking loss decreased significantly with increasing the level of camel meat in fresh sausage formula; moreover, with prolonging the storage period to 14 days at –18 °C. Babiker and Tibin [29] and FAO [23, 30] reported that the level and type of fat in emulsion type sausages affected the percentage of cooking losses. In this regard, Serdaroglu et al. [31, 32] found that there is a possible relationship between increasing cooking yield and higher fat retention in beef patties.

Moisture and fat retention

Moisture retention of the samples increased with more camel meat addition ($p < 0.05$) as observed in Fig. 1. Burgers manufactured with various levels of camel meat

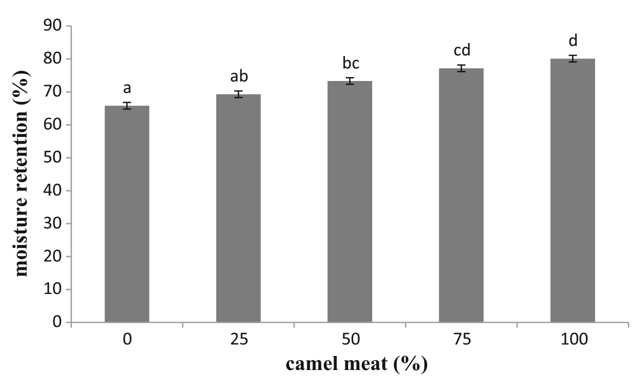

Fig. 1 Effect of camel meat replacement on moisture retention of burgers. *Column bars* with different alphabet indicate significant difference ($p < 0.05$)

were shown no significant differences ($p > 0.05$) in fat retention. Burgers in day 0 had higher ($p < 0.05$) fat retention than the other days, but were shown no significant differences ($p > 0.05$) in moisture retention under storage for 3 months at −18 °C. Moisture and fat retention are dependent on the ability of protein matrix to retain water and bind fat [33]. Despite of insignificant difference in fat retention, the burgers manufactured from camel meat had higher moisture and fat retention. These results were in line with those of Elsharif [28] in camel meat sausage in which it was mentioned that camel meat sausages had better retention capacity of water and fat during cooking than those made with beef.

Diameter reduction and thickness increase

With respect to diameter reduction, control burgers showed more reduction in diameter ($p < 0.05$) after cooking than camel meat burgers (Fig. 2). Increase in thickness decreased insignificantly ($p > 0.05$) with more camel meat addition and showed the highest level in control samples (17.6 %). Storage period did not affect ($p > 0.05$) the diameter reduction and thickness increase of cooked burgers. These results were in line with those of Besbes et al. [34] and Farouk et al. [35] who found that denaturation of meat proteins and loss of water and fat simultaneously, is the reason of reduction in diameter.

Shrinkage

Neither storage period nor camel meat level had significant effect on shrinkage of burger samples ($p > 0.05$). But generally shrinkage decreased with increasing the level of camel meat. As the 0 and 100 % levels of camel meat burgers showed the highest (26.9 %) and lowest (20.8 %) percent of shrinkage respectively; in addition, the correlation analysis indicated that shrinkage is highly correlated ($r^2 = 0.9981$) with diameter reduction as an important cooking properties. A higher level of shrinkage generally refers to increased hardness. In contrast, a lower level of shrinkage leads to the expectation of a juicier and tenderer cooked meat product. The correlation analysis conducted by Du and Sun [36] showed that the cooking shrinkage in surface area is very significantly correlated with cooking loss during cooking of meat. We also found that shrinkage had a high negative linearity correlation with cooking yield ($r^2 = 0.95$). Shrinkage causes dismissal of fluid from the meat, which leads to loss of mass. Shrinkage of cooked meats increases with the volume of water eliminated; the more water is removed, the greater the pressure imbalance produced between the interior and the exterior of the meat, which creates contracting stresses leading to shrinkage and changes in its shape [37]. On the basis of these results we can come to the conclusion that high moisture retention of camel meat is the reason of decrease in burger's shrinkage along with (while the level of camel meat is increasing) camel meat increase. According to Babiker and Tibin [9] water holding capacity is superior in camel meat than beef and that superiority explained adaptation of camel to its dry habitat. On the other hand Elsharif [28] explained this function was indicated the other water parameters, cooking loss, shrinkage and drip loss.

Color

In the present study, as seen in Fig. 3, increasing the level of camel meat had a significant effect on the L^* and b^* values of cooked burgers ($p < 0.05$) but not on a^* ($p > 0.05$), also no differences ($p > 0.05$) were found between treatments and the control with increasing the camel meat in raw burger.

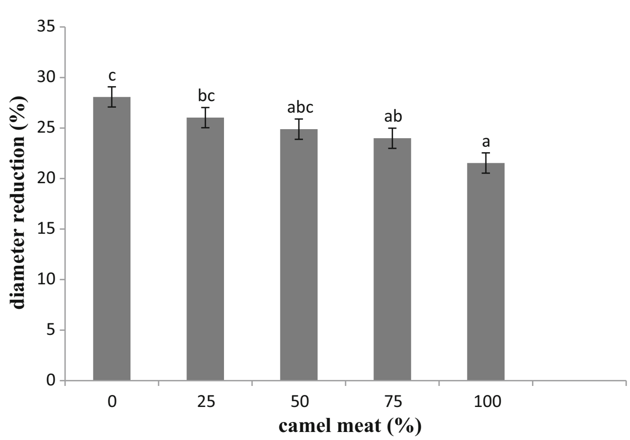

Fig. 2 Effect of camel meat replacement on diameter reduction of burgers. *Column bars* with different alphabet indicate significant difference (p < 0.05)

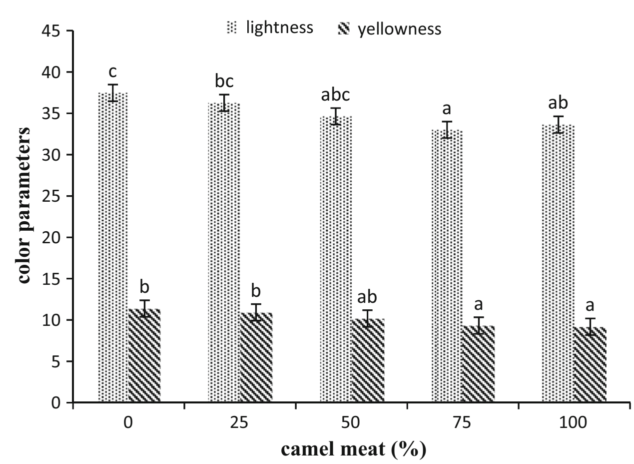

Fig. 3 Effect of camel meat replacement on color parameters of burgers. *Column bars* with different alphabet indicate significant difference (p < 0.05)

Storage conditions had no significant ($p > 0.05$) effect on color of both raw and cooked burgers. In the case of raw burger, control samples were lighter than the other formulations, and a^* was higher in burgers containing 100 % camel meat. Regarding storage condition the highest L^* and a^* were related to day 90 and 0, respectively. Al-Qadi [38] pointed that with respect to color, redness of camel meat is maintained up to five days during the storage time. Lopez et al. [25] reported that the redness of burgers decreased as storage time increased, since redness values declined very rapidly during the first 6 days of storage. Furthermore, Phillips et al. [39] reported decrease in redness values of ground beef related to longer storage time. During heating meat products several reactions would occur, including Maillard reaction, protein denaturation, and fat and water loss. These reactions are responsible for color and taste development of cooked products [40]. Hunt et al. [41] have reported that the reduction of lightness during the cooking process in meat products could be related to both the changes in myoglobin (Mb) states and also to the release of water. Accordingly, these facts might have been the reasons of reduction in lightness after cooking in both camel and beef burgers in our research.

Texture

Analysis of variance indicated that Springiness was the only textural parameter which showed significant decrease ($p < 0.05$) as the amount of camel meat increased (Fig. 4) whereas hardness, cohesiveness, gumminess and chewiness showed no significant decrease ($p > 0.05$) between different formulations. In the case of storage time, cohesiveness was the only textural parameter that showed significant decrease ($p < 0.05$) during 3 months. The day 0 had significantly higher cohesiveness than the other days, and the storage time had no significant effect on the rest of textural parameters ($p > 0.05$).

In comminuted meat products, texture related attributes are closely related to the functionality of muscle proteins, particularly their gel-forming and emulsification properties which are influenced by the presence of non-meat ingredients [42]. Gregg et al. [43] found a high correlation ($r = 0.86$) between fat content and hardness in bologna sausages. These authors and Claus et al. [44] found a similar correlation between hardness and added water. Low-fat comminuted meat products tend to be tougher than higher fat products [45, 46]. Our findings showed the same result, as hardness decreased along with reducing in fat content. In several studies, based on level of reduction, the fat content had no significant effect on springiness [47–49], or produced greater springiness when fat content was reduced [43, 50, 51]. In addition, Youssef and Barbut [52] reported that springiness values were higher in the all meat treatments compared to the non-meat protein replacements. This is probably because the non-meat proteins could hold more water and fat and/or filling the interstitial spaces within the meat protein matrix. Similarly, in our study springiness increased when the amount of camel meat decreased. Therefore, one can say, it can be due to decreasing the amount of fat, fat retention, and moisture retention in burgers by reducing the level of camel meat.

The shrinkage in measurements has a positive correlation with the textural attributes. These findings with regard texture properties may be attributed to the moisture and fat retention capacity of camel meat.

Sensory properties

Rankings by the sensory panel demonstrated that increasing the camel meat in formulation resulted in significant ($p < 0.05$) increase in juiciness, texture, flavor and overall acceptability scores (Fig. 5) and significant ($p < 0.05$) decrease in color score. Storage time significantly affected

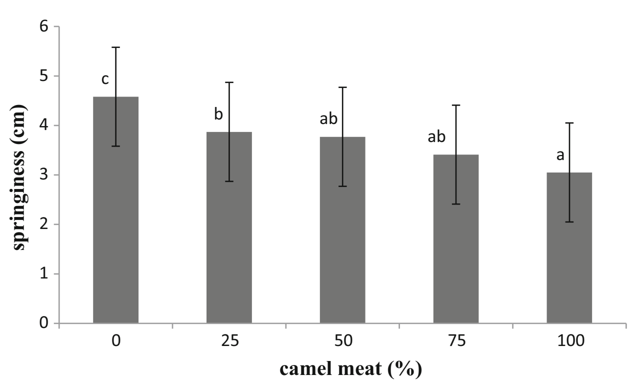

Fig. 4 Effect of camel meat replacement on springiness of burgers. *Column bars* with different alphabet indicate significant difference ($p < 0.05$)

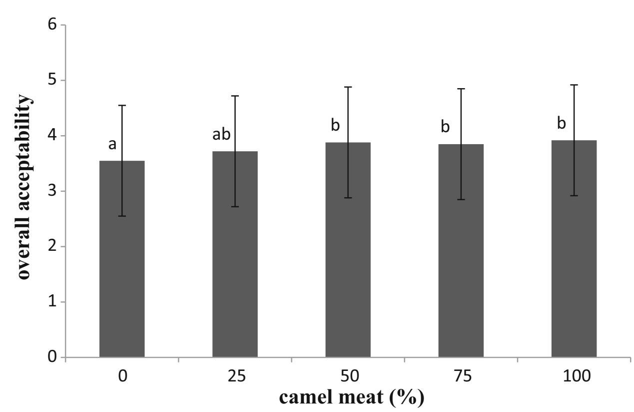

Fig. 5 Effect of camel meat replacement on overall acceptability of burgers. *Column bars* with different alphabet indicate significant difference ($p < 0.05$)

texture and flavor ($p < 0.05$) but no significant differences were found in Juiciness, color and overall acceptability scores during 3 months ($p > 0.05$).

Our results agreed with Elsharif [28] who reported that sensorial scores of sausage increased significantly with increasing the level of camel meat.

The burger including 100 % of camel meat had the higher score in juiciness which it may be due to the fat content, higher capacity in fat and water retention of camel meat.

Park et al. [53] reported that reduction of fat content in frankfurters is the reason of decreasing juiciness. These results were supported by Johnson [54] who mentioned that differences in juiciness were related basically to the ability of muscle to retain water during cooking. This confirms what has been reported by Johnson [54] and Deatherage [55] that difference in juiciness is related primarily to the ability of muscle to retain water during cooking and led in an increase in juiciness of emulsion types of meat and other products.

The 100 % level showed the lowest score in lightness color as compared with the 0 % level. This may be due to the lowest values of lightness in camel meat; moreover, as same as our findings, changes in color of stored ground beef were found by Hunt et al. [56].

The results showed that the panel scores for texture, flavor and overall acceptability increased with increasing the added level of camel meat. However, with regard to the overall acceptability, the samples containing both 50 and 100 % of camel meat were the highest acceptable samples. Sensory evaluation results verify that fat content in formulation improved the texture, flavor and overall acceptability. These findings agreed with Berry et al. [57] and Troutt et al. [58] who showed that the decrease of fat level in meat products results in reduction of the flavor intensity. Ahmed et al. [45] and Serdaroglu and Sapancı-Ozsumer, [46] reported that low-fat comminuted meat products tend to be tougher than higher fat products.

Conclusion

In conclusion, increasing the level of camel meat from 0 to 100 % on burger formulation resulted in an increase of cooking yield, moisture retention and fat retention. 0 and 100 % level of camel meat burger showed respectively the lowest and highest diameter reduction. However, the result contrasted with increasing of thickness. The 100 % level showed the highest decrease in springiness, hardness, cohesiveness, gumminess and chewiness values as compared with the 0 % level. Oxidative rancidity (TBA-RS) values increased with increasing the camel meat. The sensory panel rating of juiciness, texture, flavor and overall acceptability increased but color decreased with increasing the added level of camel meat.

Compliance with ethical standards

Ethical statements The manuscript does not contain clinical studies or patient data.

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