A comparative Study of Some Nutritional Aspects of Camel and Cattle Meats and the Effect of Chilling and Freezing Storage on the Meat Lipid Peroxidation

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ABSTRACT

The present work aimed to study and compare some nutritional aspects of cattle and camel meats of both young and old ages, and the lipid peroxidation behavior during chilling and freezing storage of such meats. A total of 36 fresh meat samples (10 of each of young and old cattle, 9 of young and 7 of old camel) were randomly collected from butcher shops at the same day of slaughter. The pH and the proximate composition"%" (moisture, protein, fat, ash) were estimated. Carbohydrate (%) and gross energy content (Kcal/100g) were calculated. The TBA value (mg malonaldehyde/kg flesh) changes during chilling (4ºC) and freezing (-10ºC) storage was assessed. For fresh samples of young camel meat, the moisture, protein, fat, ash, carbohydrates and energy mean values were 76.36 ± 0.34, 20.13 ± 0.29, 1.89 ± 0.16, 1.06 ± 0.03, 0.56 ± 0.08, and 99.78 ± 2.01, while for young beef samples were 73.79 ± 0.47, 21.29 ± 0.35, 3.22 ± 0.26, 1.08 ± 0.04, 0.61 ± 0.09 and 116.61 ± 2.69, respectively. For fresh samples of old camel meat, the mean values were 76.35 ± 0.33, 20.36 ± 0.26, 1.64 ± 0.08, 1.05 ± 0.03, 0.60 ± 0.09, and 98.57 ± 0.33; and for old beef samples were 76.11 ± 0.57, 19.57 ± 0.48, 2.54 ± 0.26, 1.32 ± 0.11, 0.46 ± 0.07 and 102.96 ± 3.33, respectively. Protein content was comparable in both cattle and camel meats, while fat was significantly ($p<0.05$) lower in camel meat. Freezing storage results in significant ($P<0.05$) decrease in moisture, while protein and energy were significantly ($p<0.05$) increased, and other items were changed insignificantly ($P>0.05$). The pH values showed significant ($P<0.05$) increase for old ages samples but non-significant ($P>0.05$) for young ages during chilling storage. The TBA values showed steady increase in all samples during chilling and freezing storage, the rate of increase was lower in camel meat than in beef. In conclusion, camel meat ranked superior to that of cattle of nearly similar age "had significantly lower fat content and keep longer at chilling and freezing".

Key words: Camel Meat, Beef, Young, Old, Proximate Composition, TBA, Chilling, Freezing.

INTRODUCTION

Meat is essential component in the diets of humans known as an excellent source of high biological value protein beside many other nutrients (Nfor et al., 2014). In Egypt, cattle are considered the main source of red meat for the population, other species including buffaloes, camel, sheep and goats contribute to meat supplementation in less extent (Ahmed et al., 2013). Cattle's head population in Egypt was estimated to be 1,392,430 in the year 2017 while that of camels was only 122,967 (FAOSTAT, 2018).

Compared to beef, the contribution of camel meat to the per capita meat consumption in the world is not impressive. The world camel meat production represents only about 1.3% of the total world meat production (FAOSTAT, 2011). Likewise, in Egypt camel meat production and consumption ranked so much lower in comparison to beef. Samaha and Draz (1993) reported that beef constitutes about 36.88 % of the total red meat produced in Egypt compared to 6.63 % for camel meat. The production of cattle meat reached 456,359 tonnes by the year 2017 with annual per capita consumption of 4.8kg, while that of camel reached 39,606 tonnes with annual per capita consumption of 0.42kg (FAOSTAT, 2018). The world annual per capita consumption of meat found to be continuously increasing (FAO, 2007). The one-humped dromedary camel can be a viable alternative to cattle in meat production, to alleviate the growing demand for red meat in

developing countries with affordable prices. The Arabian camel can be raised more economically than cattle especially in the desert regions, because of its ability to withstand harsh environmental conditions which is not matched by any other red meat animal species (Babiker and Yousif, 1990; Elgasim and Alkanhal, 1992, Gheisari et al., 2009).

Consumer concerns on the quality of meat and meat products had greatly increased during past decades because of its significant relation to the nutritive value. The protein, fat, moisture and ash content of meat considered as important quality parameters, besides the nutritive value of meat is determined by its chemical composition, in particular the content of protein and intramuscular fat (Gheisari, 2011; Alkhanky Sheryhan, 2015; Łozicki et al., 2017). Moisture content plays an important role in meat preservation and eating quality whereas the palatability and manufacturing quality of meat related to its protein and fat contents (Kadim et al., 2008b). Protein from meat has a high biological value and is of high quality for being rich in all the essential amino acids in well balanced proportions and concentration (Nfor et al., 2014). Fat as well, affects the sensory characteristics (e.g. flavor and texture) of the meat and is a vital nutrient with many functions in the human body. (McAfee et al., 2010; Schmid, 2011). However, the high level of saturated fats in meat considered to be the main factor of several diseases of modern civilization such as cardiovascular diseases, obesity, or cancer (Ulbricht and Southgate, 1991; Jiménez-Colmenero et al., 2001; Leosdottir et al., 2005). The chemical composition of meat varied according to the animal species, breed, age, sex, feeding type and body weight (Romans et al, 1994; Soeparno, 1994; Tariq et al, 2013; Łozicki et al., 2017).

Camel meat besides being tough and firm as obtained from aged animals "seven years or more", is wrongly believed to be of lower quality and nutritive value than other types of red meat, causing general reluctance to consume it worldwide. In Egypt camel meat is not so much consumed except in some localities of Egyptian governorates e.g. Belbies, El-Sharkia and Bani Adei, Assuit. Studies, however, declared that camel meat is similar in taste and texture to beef when animals are slaughtered at comparable ages (Williams, 2002; Finke, 2005; Kadim et al., 2008a; Kadim et al., 2011). Moreover, the nutritive value of camel meat was found to be similar or sometimes superior compared to other types of red meat (beef, mutton); have more moisture, less fat, less ash and similar protein contents (Elgasim and Alkanhal, 1992; Dawood and Alkanhal, 1995; Skidmore, 2005; Kadim et al., 2008b; Gheisari et al., 2009). Also, camel meat can be considered functionally healthier than beef or mutton due to its lower intramuscular fat with higher content of polyunsaturated fatty acid and low cholesterol "renders it recommended food for population in reducing the risk of cardiovascular disease related to saturated fat consumption" (Rawdah et al., 1994; Dawood and Alkanhal, 1995; Kadim et al., 2008b).

Meat may be sold immediately in the fresh state; chilled; or stored frozen. During storage and marketing, at cooler (chilling or freezing) temperatures, meat is usually subjected to deteriorative changes in sensory, physical and chemical properties **(**Soyer et al., 2010; Samuela et al., 2011). Such changes affect its nutritive value and eating quality which is the most important for consumer acceptance. Preservation was generally assumed to be satisfactory as long as the food was frozen hard, and little attention was paid to the quality or nutritional value **(**Miller et al., 1980; Popova et al., 2009; Akhtar et al., 2013; Taha et al., 2014; Bağdatli Aytunga and Kayaardi Semra, 2015**)**.

The pH of meat is probably the quality attribute most commonly measured being affects its technological properties, keeping ability and most sensory traits. Good quality meat usually has a pH of 5.4–5.7. The rise of pH value during cold (chilling or freezing) storage may be attributed to the possible breakdown of proteins and consequently the increase of ammonia and free amino groups; compounds of alkaline reactions. (Gheisari et al., 2009; Kesavan et al., 2014; Bağdatli Aytunga and Kayaardi Semra, 2015).

The oxidation of lipids leading to rancidity is an important profound change occurs during cold storage of meat, being one of the major determinants of meat quality (Rosmini et al., 1996). It takes place in polyunsaturated fatty acids resulted in oxidized products that have negative impact on

the aroma, color, flavor and nutritive value of meat, besides being harmful to human health and of toxic effect for consumers (Jakobsen and Bertelsen 2000; Sasaki et al., 2001; Kamal-Eldin and Yanishlieva, 2002; Alderton et al., 2003). Meat from different species may show different rates of oxidation because of the difference in the amount of fats and fatty acid composition (Widayaka et al., 2001). Studies have shown that cold storage leads to time dependent accumulation of lipid peroxidation products in meat (Wills et al., 2004, Okolie et al., 2009; Popova et al., 2009; Okolie and Okugbo, 2013; Taha et al, 2014), where oxidation occurs at slow rate but not stopped since the reactive species are soluble in the lipid fraction and stable at low temperatures (Zarzycki and Swiniarska, 1993). Malondialdehydes (MDA), a major degradation product of meat lipid peroxidation, is of particular concern for human health in view of its well-known mutagenic and carcinogenic effects. MDA can be absorbed from tainted foods when these foods are ingested, where it reacts with the DNA and form highly mutagenic adducts in human cells (Riggins and Marnett, 2001; Giron Calle et al., 2002; Cline et al., 2004; Del Rio et al., 2005).

In Egypt, camel meat compared to beef has received little attention in studies (Elsharawy Nagwa, 2018). As well, the peroxidation of the meat lipids during storage and marketing is an important issue related to the quality and consumer acceptance and health. For that, the current study was planned out to investigate and compare: a) some nutritional aspects of camel and cattle meats of two age groups; b) the change in pH value and the peroxidation of meat lipids during chilling storage; c) the change in the basic chemical composition and the peroxidation of meat lipids during freezing storage of camel meat as compared to beef; declaring if any differences present when considering the species and/or age of the animal.

MATERIAL AND METHODS

Of the fresh meat, sum of 36 samples "½kg each" (10 of each of young and old cattle, 9 of young and 7 of old camel) were randomly collected, early at the day of slaughter, from butcher shops over a period of one and half month. Cattle up to 3 years was the young age, that over 3 years was the old, while camel up to 5 years was the young and that over 5 years was the old age. The collected samples were directly dispatched to the laboratory, in an ice box, with a minimum of delay where any visible fat was removed and the lean muscle part was immediately kept refrigerated (4ºC) for a period of 24hrs for cattle meat and 48hrs for camel meat, before the start of analysis. For the four age groups (young and old cattle, and young and old camel), each sample was divided into two parts, one part kept at chilling (4ºC) and used for determination of the proximate composition (moisture, protein, fat, ash) at the fresh state and for studying the changes in pH and the meat lipid peroxidation "TBA value" during chilling storage; the other part was kept frozen at -10ºC up to 180 days for determination of the meat lipid peroxidation "TBA value" during freezing storage, and the proximate composition by the end of the freezing storage period.

The pH

The pH value was measured 24hrs (cattle) - 48hrs (camel) of chilling (fresh sample); and by the end of the chilling period "end of shelf life". According to Lyhs et al. (1998), of the sample10g was stomached with 100-mL distilled water for 2 min. The pH of the homogenate was measured at room temperature using a digital pH meter (Lovibond, SD50) standardized at pH 7.

Proximate composition and gross energy content

Proximate composition (moisture, protein, fat, ash) in fresh samples 24hrs (cattle) – 48hrs (camel) after chilling; and by the end of freezing storage period (180 days), was estimated as percentages according to the methods of AOAC (2000).

Protein was estimated using macro-Kjeldahal method multiplying by the factor 6.25.

For fat, Soxhlet method with slight shift was applied, 1g dried sample was weighed and wrapped in filter paper of known weight, after extraction the loss in weight was calculated as the fat percentage.

The estimated percentages of protein, fat and ash on dry weight basis were converted, into wet weight basis before used for next calculations. The following equation was applied (Jurgens and Bregendahl, 2007):

$$\text{Nutrient wet basis \%} = \frac{\text{Nutrient dry basis \% x Dry matter \%}}{100}$$

Carbohydrate percentage was calculated by difference as following:

Carbohydrate % = 100 – (moisture % + protein % + fat % + ash %)

The gross energy content (Kcal/100g) was calculated according to the equation of Merrill and Watt (1973):

Gross energy value = (protein % x 4) + (fat % x 9) + (carbohydrate % x 4)

The lipid peroxidation (Thiobarbituric Acid Reactive Substances (TBARS or TBA) value "mg malonaldehyde/kg flesh")

Meat lipid peroxidation level (TBA value) was measured in both chilling and freezing stored samples:

For chill stored samples, TBA measurements was applied 24hrs "cattle" or 48hrs "camel" after chilling, and then daily or day after day with no regular basis till the end of the chilling storage period (7-11 days).

For freeze stored samples, TBA value was estimated in fresh samples (24 or 48hrs of chilling), then at 15, 30, 60, 90,120,150 and 180th day of freezing storage.

The TBA value was assessed according to the procedures of Buege and Aust (1978). Absorbance was measured using Unico UV- 2100 spectrophotometer (USA) at 531 nm.

Statistics

The obtained data subjected to ANOVA analysis using SPSS (2001) program. The data represented as mean ± standard error (mean ± SE). The significance difference between means was calculated at level $P<0.05$ or $P<0.01$.

RESULTS

The results in Table (1) declared the proximate composition (%) of analyzed meat samples. For fresh chilled samples, young camel meat showed content (%) of moisture, protein, fat, ash, and carbohydrate in the range of 75.02 – 77.65, 18.83 – 21.19, 0.95 – 2.54, 0.91 – 1.20, and 0.15 – 0.97 with mean value of 76.36 ± 0.34, 20.13 ± 0.29, 1.89 ± 0.16, 1.06 ± 0.03, and 0.56 ± 0.08, respectively. Energy content (Kcal/100g) was in the range of 90.31 – 108.98 with mean of 99.78 ± 2.01. Regarding young cattle, the moisture, protein, fat, ash, and carbohydrate percentages ranged from 72.00 to 76.57, 19.39 to 22.99, 1.67 to 3.91, 0.94 – 1.34, and from 0.14 to 0.94 with mean value of 73.79 ± 0.47, 21.29 ± 0.35, 3.22 ± 0.26, 1.08 ± 0.04, and 0.61 ± 0.09, respectively. The energy content ranged from 98.27 to 123.46 with mean of 116.61 ± 2.69. Considering old camel meat samples the moisture, protein, fat, ash, and carbohydrate percentages were in the range of 74.98 – 77.36, 19.54 – 21.33, 1.37 – 1.9, 0.98 - 1.21, and 0.21 - 0.90 with mean value of 76.35 ± 0.33, 20.36 ± 0.26, 1.64 ± 0.08, 1.05 ± 0.03, and 0.60 ± 0.09, respectively. The energy was in the range of 93.79 – 105.38 with mean of 98.57 ± 0.33. As for old cattle samples, the moisture, protein,

fat, ash, and carbohydrate ranged from 71.97 to 78.52, 17.35 - 21.96, 1.72 to 4.58, 0.92 to 2.18, and from 0.17 to 0.87 with mean value of 76.11 ± 0.57, 19.57 ± 0.48, 2.54 ± 0.26, 1.32 ± 0.11, and 0.46 ± 0.07, respectively. The energy ranged from 89.33 to 129.74 with mean of 102.96 ± 3.33. Significant differences ($P<0.05$) was found between the mean values of some variables, while between some others the differences was insignificant ($P>0.05$).

In freezing (-10°C) stored meat samples of young camel at 180th day of freezing, the minimum, maximum and mean values (%) of moisture were 71.19, 75.42 and 73.53 ± 0.48; of protein 18.65, 22.82 and 22.46 ± 0.40; of fat 1.41, 3.45 and 2.48 ± 0.23; of ash 0.37, 1.3 and 0.97 ± 0.12, and of carbohydrate 0.37, 0.89 and 0.57 ± 0.06, respectively. The values for energy content (Kcal/100g) were 105.22, 125.26 and 114.39 ± 2.54, respectively. Regarding young cattle meat samples, the minimum, maximum and mean values (%) were 68.15, 74.04 and 70.90 ± 0.64 for moisture; 22.09, 26.42 and 23.79 ± 0.46 for protein; 2.08, 5.72 and 3.70 ± 0.34 for fat; 0.58, 1.33 and 1.09 ± 0.07 for ash; and 0.11, 0.95 and 0.52 ± 0.09 for carbohydrate, respectively. For energy the values were 113.46, 151.62 and 130.54 ± 3.82, respectively. With respect to old camel meat samples the previous values (%) of moisture were 71.86, 74.45 and 73.53 ± 0.32; of protein 21.81, 23.71 and 22.62 ± 0.24; of fat 1.72, 3.32 and 2.27 ± 0.20; of ash 0.78, 1.28 and 0.98 ± 0.06; and of carbohydrate 0.28, 0.87 and 0.59 ± 0.08, respectively. The values for energy were 108.77, 120.62 and 113.32 ± 1.82, respectively. In old cattle meat samples, the minimum, maximum and mean values were 72.25, 75.83 and 74.24 ± 0.39 for moisture; 18.65, 22.82 and 20.90 ± 0.44 for protein; 2.33, 4.41 and 3.17 ± 0.20 for fat; 0.5, 1.66 and 1.13 ± 0.11 for ash; and 0.37, 0.89 and 0.55 ± 0.06 for carbohydrate. The values for energy were 106.28, 121.78 and 114.38 ± 2.02, respectively. The mean values of some variables were significantly ($P<0.05$) differ, while of some others were differ insignificantly ($P>0.05$) "Table 1".

The data in Table (2) showed the change in pH values during chilling (4°C) storage of fresh meat samples. For young ages, the pH values in camel meat "48hrs of chilling" were in the range of 5.8–6.05 with mean of 5.95 ± 0.04; and in cattle meat "24hrs of chilling" were in the range of 5.53–6.13 with mean of 5.79 ± 0.06. By the last day of chilling life, the values ranged from 5.51 to 6.89 with mean of 6.18 ± 0.15 for camel meat; and from 5.60 to 6.62 with mean of 6.09 ± 0.11 for beef. Regarding old ages, the pH values in camel meat samples "48hrs of chilling" were in the range of 5.75–6.27 with mean of 6.03 ± 0.08, while in cattle samples "24hrs of chilling" were in the range of 6.06–7.74 with mean of 6.82 ± 0.21. By the last day of chilling life, the values were in the range of 6.09 – 6.97 with mean of 6.46 ± 0.12 for camel meat; and in the range of 6.24-7.96 with mean of 7.19 ± 0.17 for beef. The pH change was significant ($P<0.05$) for old ages, but for young ages was not ($P>0.05$).

Table (3) and Figure (1) declared the meat lipid peroxidation behavior (changes in TBA value) (mg malonaldehyde/kg flesh) during chilling (4°C) storage of the meat samples. For all ages, samples showed irregular steady increase in meat lipid peroxidation during chilling storage. For young camel meat samples, TBA values "48hrs of chilling storage" were in the range of 0.075–0.480 with mean of 0.237±0.048, and by the end of chilling shelf-life (8th day) were in the range of 0.05–1.078 with mean of 0.472±0.132. In young beef samples the values "24hrs of chilling" were in the range of 0.012 –0.374 with mean of 0.149 ± 0.041, and by the end of chilling shelf-life (7th day) were in the range of 0.044–1.551 with mean of 0.784±0.189. Regarding old ages, the TBA values of camel meat samples "48hrs after chilling" were in the range of 0.118–0.349 with mean of 0.219±0.042; and by the end of chilling shelf-life (10th day) were in the range of 0.343–0.754 with mean of 0.554±0.088. However, in old beef samples the values "24hrs of chilling storage" ranged from 0.044 to 0.374 with mean of 0.222±0.041, and by the end of chilling shelf-life (6th day) ranged from 0.137 to 0.810 with mean of 0.384±0.064. TBA values showed significant ($P<0.05$) increase in young camel meat samples, while in young beef the increase was highly significant ($P<0.01$). For old camel meat samples the increase was significant ($P<0.05$), but in old beef it was insignificant ($P>0.05$).

Table 1: Proximate composition[1] (%) and energy content (Kcal/100g) of the examined camel and cattle meat samples (Mean ± SE) / (Min – Max)[2].

Variables	Fresh chilled[3]				Freeze (-10°C) stored[4]			
	Young		Old		Young		Old	
	Camel (9)[5]	Cattle (10)	Camel (7)	Cattle (10)	Camel (9)	Cattle (10)	Camel (7)	Cattle (9)
Moisture (%)	76.36^{a} ± 0.34 (75.02 – 77.65)	73.79^{b} ± 0.47 (72.00 – 76.57)	76.35^{a} ± 0.33 (74.98 – 77.36)	76.11^{a} ± 0.57 (71.97 – 78.52)	73.53^{b} ± 0.48 (71.19 – 75.42)	70.90^{c} ± 0.64 (68.15 -74.04)	73.53^{b} ± 0.32 (71.86 – 74.45)	74.24^{b} ± 0.39 (72.25 – 75.83)
Protein (%)	20.13^{de} ± 0.29 (18.83 – 21.19)	21.29^{cd} ± 0.35 (19.39 – 22.99)	20.36^{de} ± 0.26 (19.54 – 21.33)	19.57^{e} ± 0.48 (17.35 – 21.96)	22.46^{bc} ± 0.40 (18.65 – 22.82)	23.79^{a} ± 0.46 (22.09 – 26.42)	22.62^{b} ± 0.24 (21.81 – 23.71)	20.90^{d} ± 0.44 (18.65 – 22.82)
Fat (%)	1.89^{cd} ± 0.16 (0.95 – 2.54)	3.22^{ab} ± 0.26 (1.67 – 3.91)	1.64^{d} ± 0.08 (1.37 – 1.9)	2.54^{bc} ± 0.26 (1.72 – 4.58)	2.48^{c} ± 0.23 (1.41 – 3.45)	3.70^{a} ± 0.34 (2.08 – 5.72)	2.27^{cd} ± 0.20 (1.72 – 3.32)	3.17^{ab} ± 0.20 (2.33 – 4.41)
Ash (%)	1.06^{b} ± 0.03 (0.91 – 1.20)	1.08^{ab} ± 0.04 (0.94 – 1.34)	1.05^{b} ± 0.03 (0.98 – 1.21)	1.32^{a} ± 0.11 (0.92 – 2.18)	0.97^{b} ± 0.12 (0.37 – 1.3)	1.09^{ab} ± 0.07 (0.58 – 1.33)	0.98^{b} ± 0.06 (0.78 – 1.28)	1.13^{ab} ± 0.11 (0.5 – 1.66)
Carbohydrate (%)	0.56^{a} ± 0.08 (0.15 – 0.97)	0.61^{a} ± 0.09 (0.14 – 0.94)	0.60^{a} ± 0.09 (0.21 - 0.90)	0.46^{a} ± 0.07 (0.17 – 0.87)	0.57^{a} ± 0.06 (0.37 – 0.89)	0.52^{a} ± 0.09 (0.11 – 0.95)	0.59^{a} ± 0.08 (0.28 – 0.87)	0.55^{a} ± 0.06 (0.37 – 0.89)
Energy (Kcal/100g)	99.78^{c} ± 2.01 (90.31 – 108.98)	116.61^{b} ± 2.69 (98.27 – 123.46)	98.57^{c} ± 0.33 (93.79 – 105.38)	102.96^{c} ± 3.33 (89.33 – 129.74)	114.39^{b} ± 2.54 (105.22 – 125.26)	130.54^{a} ± 3.82 (113.46 – 151.62)	113.32^{b} ± 1.82 (108.77 – 120.62)	114.38^{b} ± 2.02 (106.28– 121.78)

[1] Wet weight basis [2] Mean ± SE = Mean ± Standard Error [2] Min= minimum value [2] Max= maximum value
[3] 24hrs of chilling for cattle and 48hrs of chilling for camel [4] Last (180^{th}) day of freezing [5] Number of samples analyzed
Within the same row means with different superscripts are significantly differ (P<0.05)

Table 2: The change of pH values of fresh camel and cattle meat samples during chilling (4°C) storage (Mean±SE) / (Min–Max).

Times of measurement	Young		Old	
	Camel (n=9)	Cattle (n=10)	Camel (n=7)	Cattle (n=10)
Initial[1]	5.95^{de} ± 0.04 **(6)**[2] (5.8 – 6.05)	5.79^{e} ± 0.06 **(10)** (5.53 – 6.13)	6.03^{de} ± 0.08 **(5)** (5.75 – 6.27)	6.82^{b} ± 0.21 **(7)** (6.06 – 7.74)
Last day of chilling life[3]	6.18^{cd} ± 0.15 **(9)** (5.51 – 6.89)	6.09^{cde} ± 0.11 **(10)** (5.60 – 6.62)	6.46^{bc} ± 0.12 **(6)** (6.09 – 6.97)	7.19^{a} ± 0.17 **(10)** (6.24 – 7.96)

Mean ± SE = Mean ± Standard Error Min= minimum value Max= maximum value
n= Number of samples [1] 24hrs for cattle and 48hrs for camel meat samples [2] Number of samples tested
[3] 8th day for young camels, 7th day for young cattle, 10th day for old camels, 6th day for old cattle meat samples
Means with different superscripts are significantly differ (P<0.05)

Table 3: The changes of TBA values (mg malonaldehyde/kg flesh) of fresh camel and cattle meat samples during chilling (4°C) storage (Mean ± SE) / (Min – Max).

Days of storage	Young		Old	
	Camel[3] (n=9)	Cattle[4] (n=10)	Camel[3] (n=7)	Cattle[3] (n=10)
1st*	N	0.149^{c} ± 0.041 **(9)** (0.012 – 0.374)	N	0.222^{b} ± 0.041 **(8)** (0.044 – 0.374)
2nd**	0.237^{bd} ± 0.048 **(9)**[1] (0.075 – 0.480)	0.165^{c} ± 0.045 **(10)** (0.019 – 0.505)	0.219^{bc} ± 0.042 **(5)** (0.118 – 0.349)	0.239^{b} ± 0.033 **(8)** (0.131 – 0.393)
3rd	N	0.260^{c} ± 0.039 **(9)** (0.037 – 0.449)	N	0.278^{bc} ± 0.047 **(8)** (0.062 – 0.43)
4th	0.328^{cd} ± 0.081 **(7)** (0.125 – 0.723)	0.333^{bc} ± 0.079 **(8)** (0.106 – 0.648)	0.301^{bc} ± 0.055 **(7)** (0.137 – 0.567)	0.350^{bc} ± 0.054 **(9)** (0.150 – 0.567)
5th	0.334^{cd} ± 0.105 **(6)** (0.1 – 0.798)	0.643^{ab} ± 0.112 **(8)** (0.143 – 1.215)	0.302^{bc} ± 0.038 **(6)** (0.174 – 0.436)	0.376^{ac} ± 0.054 **(8)** (0.181 – 0.660)
6th	0.340^{cd} ± 0.079 **(7)** (0.1 – 0.779)	0.757^{a} ± 0.137 **(9)** (0.131 – 1.327)	0.314^{cd} ± 0.069 **(6)** (0.162 – 0.505)	0.384^{bc} ± 0.064 **(10)** (0.137 – 0.810)
7th	0.358^{cd} ± 0.132 **(6)** (0.025 – 0.822)	0.784^{a} ± 0.189 **(9)** (0.044 – 1.551)	0.370^{cd} ± 0.139 **(6)** (0.062 – 1.009)	N
8th	0.472^{cd} ± 0.132 **(8)** (0.05 – 1.078)	N	0.376^{cd} ± 0.130 **(6)** (0.118 – 0.992)	0.387^{bc} ± 0.113 **(7)**[2] (0.162 – 0.972)
9th	N	0.852^{a} ± 0.308 **(4)**[2] (0.125 – 1.408)	0.520^{cd} ± 0.138 **(4)** (0.118 – 0.741)	-
10th	0.595^{ac} ± 0.163 **(6)**[2] (0.131 – 1.184)	-	0.554^{ad} ± 0.088 **(6)** (0.343 – 0.754)	-
11th	-	-	0.667^{ad} ± 0.20 **(2)**[2] (0.467 – 0.866)	-

Mean ± SE = Mean ± Standard Error Min= minimum value Max= maximum value
* 24hrs of chilling storage ** 48hrs of chilling storage n= Number of samples
[1] Number of samples tested [2] The other samples were organoleptically unaccepted N= not detected
Within the same column means with different superscripts are significantly different (P<0.05)[3], (P<0.01)[4]

The data in Table (4) and Figure (2) explains the meat lipid peroxidation behavior (mg malonaldehyde/kg flesh) during freezing (-10°C) storage of meat samples; which showed a time dependent increase pattern of TBA values for all ages. In young camel meat samples, the TBA values increased from 0.237 ± 0.048 (0.075–0.480) at day zero to 1.044 ± 0.153 (0.417–1.850) by the day 180th of freezing storage; while in young beef from 0.149 ± 0.041 (0.012–0.374) at day zero to 1.208 ± 0.032 (1.084–1.358) by the day 180th. For old camel meat samples, the values increased from 0.219 ± 0.042 (0.118–0.349) at day zero to 0.926 ± 0.191 (0.442–1.545) by the day 180th; and for old beef from 0.222 ± 0.041 (0.044–0.374) at day zero to 1.135 ± 0.062 (0.692–1.340) by the day 180th. The increase in TBA values during freezing storage was highly significant (P<0.01) for all ages.

Table 4: The changes of TBA values (mg malonaldehyde/kg flesh) of camel and cattle meat samples during freezing (-10°C) storage (Mean ± SE) / (Min – Max)

Days of storage	Young		Old	
	Camel (n=9)	Cattle (n=10)	Camel (n=7)	Cattle (n=10)
0*	0.237^{e} ± 0.048 **(9)**[1] (0.075 – 0.480)	0.149^{f} ± 0.041 **(9)** (0.012 – 0.374)	0.219^{c} ± 0.042 **(5)** (0.118 – 0.349)	0.222^{e} ± 0.041 **(8)** (0.044 – 0.374)
15th	0.319^{e} ± 0.055 **(9)** (0.075 – 0.505)	0.285^{e} ± 0.047 **(9)** (0.075 – 0.505)	0.246^{c} ± 0.043 **(6)** (0.125 – 0.349)	0.363^{de} ± 0.082 **(9)** (0.081 – 0.978)
30th	0.422^{de} ± 0.072 **(8)** (0.106 – 0.717)	0.382^{de} ± 0.057 **(8)** (0.181 – 0.685)	0.450^{bc} ± 0.057 **(7)** (0.125 – 0.573)	0.443^{d} ± 0.071 **(9)** (0.150 – 0.785)
60th	0.564^{cd} ± 0.050 **(9)** (0.249 – 0.798)	0.433^{d} ± 0.043 **(10)** (0.249 – 0.673)	0.677^{ab} ± 0.050 **(7)** (0.486 – 0.879)	0.658^{c} ± 0.061 **(10)** (0.442 – 1.022)
90th	0.682^{c} ± 0.074 **(9)** (0.368 – 0.991)	0.788^{c} ± 0.037 **(10)** (0.573 – 0.978)	0.733^{a} ± 0.078 **(7)** (0.430 – 0.972)	0.937^{b} ± 0.063 **(10)** (0.673 – 1.252)
120th	0.775^{bc} ± 0.061 **(9)** (0.411 – 0.984)	0.966^{b} ± 0.035 **(10)** (0.779 – 1.103)	0.865^{a} ± 0.070 **(7)** (0.530 – 1.028)	0.934^{b} ± 0.064 **(10)** (0.611 – 1.283)
150th	0.920^{ab} ± 0.027 **(9)** (0.798 – 1.009)	1.070^{b} ± 0.044 **(10)** (0.866 – 1.302)	0.922^{a} ± 0.102 **(7)** (0.318 – 1.065)	1.039^{ab} ± 0.053 **(10)** (0.648 – 1.308)
180th	1.044^{a} ± 0.153 **(9)** (0.417 – 1.850)	1.208^{a} ± 0.032 **(10)** (1.084 – 1.358)	0.926^{a} ± 0.191 **(6)** (0.442 – 1.545)	1.135^{a} ± 0.062 **(9)** (0.692 – 1.340)

Mean ± SE = Mean ± Standard Error Min= minimum value Max= maximum value
* Fresh meat samples 24hrs of chilling storage for cattle and 48hrs of chilling storage for camel
n= Number of samples [1] Number of samples tested
Within the same column means with different superscripts are significantly different (P<0.01)

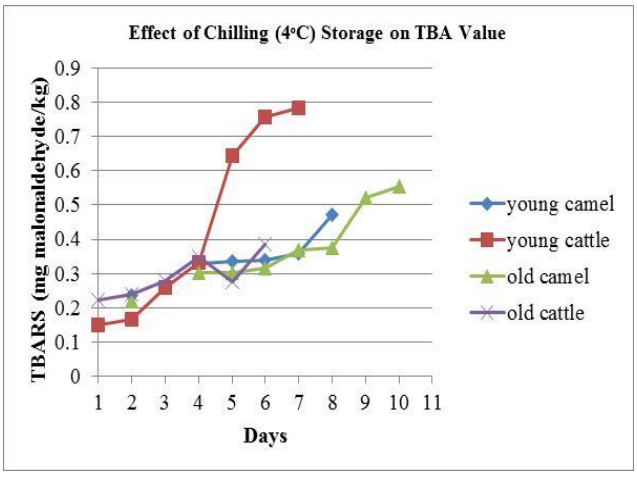

Fig (1): The changes of TBA values (mg malonaldehyde/kg flesh) during chilling (4°C) storage of meat samples

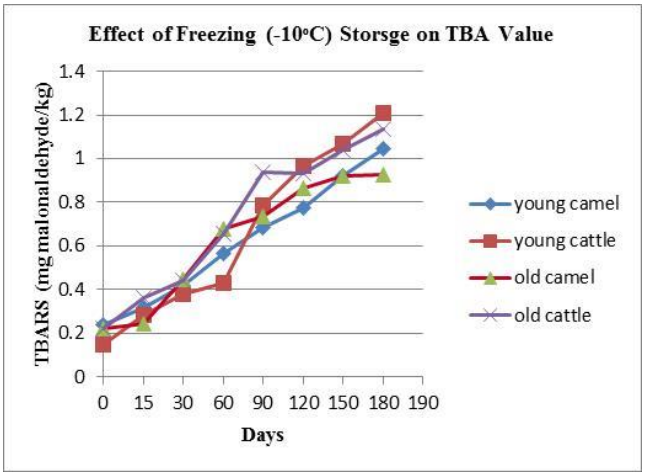

Fig (2): The changes of TBA values (mg malonaldehyde/kg flesh) during freezing (-10°C) storage of meat samples

DISCUSSION

The quality of meat including the nutritional value has recently become an important aspect for consumer acceptance and marketing. Camel meat is wrongly thought to be of lower nutritional value than beef. Many studies indicated that meat quality characteristic of camel are comparable to those of cattle when animals are slaughtered at nearly similar ages (Kadim et al., 2006; Shariatmadari and Kadivar, 2006; Gheisari et al., 2009; Kadim et al., 2009; Nikermaram et al., 2011; Alamin Siham et al, 2014). An efficient marketing system for the camel meat needs more information on its quality in relation to other species (Kadim et al., 2008a). The current study aimed to compare some aspects of the nutritive value (basic chemical composition) of camel and cattle meat; beside the effect of chilling and freezing storage on the meat lipid peroxidation.

The basic chemical composition

Meat chemical composition is generally varied according to animal species, breed, age, sex, nutrition status, health and site on the carcass. (Elgasim and Alkanhal, 1992; Madruga et al., 2006; Gheisari et al., 2009; Arain et al., 2010; Tariq et al., 2013; Abdelhadi et al., 2017). Camel meat in comparison with meat from other farm animals (beef, lamb, goat and chicken) was found to have more moisture, less fat, less ash and similar protein contents (Elgasim and Alkanhal, 1992; Kadim et al., 2008b).

The data obtained declared that for young ages, fresh camel meat compared to beef had significantly ($P<0.05$) higher moisture (76.36±0.34 vs 73.79±0.47); nearly similar ($P>0.05$) protein (20.13±0.29 vs 21.29±0.35); ash (1.06±0.03 vs 1.08±0.04) and glycogen (0.56±0.08 vs 0.61±0.09); and significantly ($P<0.05$) lower fat (1.89±0.16 vs 3.22±0.26) and gross energy (99.78±2.01 vs 116.61±2.69) mean values. As for old ages, fresh camel meat showed nearly similar ($P>0.05$) moisture (76.35±0.33 vs 76.11±0.57); protein (20.36±0.26 vs 19.57±0.48); glycogen (0.6±0.09 vs 0.46±0.07); and energy (98.57±0.33 vs 102.96±3.33); but significantly ($P<0.05$) lower fat (1.64±0.08 vs 2.54±0.26) and ash (1.05±0.03 vs 1.32±0.11) mean values when compared to beef (Table 1).

In former studies comparing chemical composition of camel and cattle meat, Kadim et al. (2008a) found an opposite trend for moisture (70.8±1.23 vs 72.3±1.35), but similar for protein (21.6±0.65 vs 22.2±0.99), fat (2.8±0.95 vs 7.8±1.01) and ash (1.3±0.03 vs 1.5±0.06) comparing *Longissimus thoracis* muscle of young Arabian camel (2-4 years) and Omani cattle (2-3 years). Nikermaram et al. (2011) recorded similar trend for moisture (76.29±0.44 vs 73.45±0.66), fat (4.38±0.39 vs 5.40±0.56), and ash (1.1±0.0 vs 0.90±0.06), but different for protein (22.14±0.95 vs 20.72±0.40) in young (1-3 years old) camel and cattle *Longissimus dorsi* muscle. Gheisari et al. (2009) in Iran compared camel (one-humped Iranian breed) and cattle (Holstein breed) muscles (*Biceps femoris*, *Triceps brachii* and *Longissmus dorsi* muscles) of young (1 year) and olds (5 years) for both sexes (male and female) and found non-significant ($p>0.05$) difference for moisture and protein (nearly similar mean values), but significant ($p<0.05$) for fat and ash contents (lower values in camel meat), which is in partial agreement with the current findings. Nearly similar trends for moisture, protein and fat, but different for ash were obtained in Sudan by Alamin Siham et al. (2014) comparing fresh camel meat and beef in Sudan. Coincide trend for moisture, fat, ash, but opposite for protein was obtained in Ismailia, Egypt, by Elsharawy Nagwa et al. (2018) comparing camel and cattle *Biceps femoris* muscle.

The results obtained for camel meat chemical composition were in the range recorded by Kadim (2013), found moisture (63.0 -77.7), protein (17.0-23.7), fat (1.1-6.2) and ash (0.69-1.38). In a former study, Ahmed (2015) estimated nearly similar moisture, higher protein, lower fat, ash, carbohydrate and gross energy mean values for young (<5 years) age camel meat; while for old (≥ 5 years)age, found lower moisture and carbohydrate, nearly similar protein, and higher fat, ash and gross energy mean values. Kadim et al. (2016) found lower moisture, but higher protein, fat and ash mean values for *Longissimus thoraces* muscle of young (2-4 years) and old (6-9 years) camels, and Abdelhadi et al. (2017) in Sudan found nearly similar mean values of moisture and protein, but higher of fat and ash for *Logissimus lumborum* muscle of young (2-3years) male and female camels, while Kimassoum et al. (2016) in Chad recorded nearly similar values of moisture and ash but lower of protein, and higher of fat in *Logissimus dorsi* muscle of old male and female camels (≥8 years). Abdelhadi et al. (2013) estimated nearly similar moisture (67.0), protein (20.6) and ash (1.12), but higher fat (4.23) contents in *Logissimus thoracis* muscle of young (3-4 years old) female camels. However, Gheisari and Eskandari (2013) found lower moisture (74.27±2.73) but higher protein (24.27±0.5), fat (4.2±0.6) and ash (1.26±0.25) in *Logissimus dorsi* muscle of 6 years old, one-humped, Iranian breed, male camels. On the other hand for beef obtained data, Kadim et al. (2008a) estimated nearly similar moisture, higher protein, fat, and ash contents in young beef (Omani cattle); Nikermaram et al. (2011) nearly similar moisture, lower protein and ash, but higher fat, while Alamin Siham et al. (2014) higher moisture, nearly similar protein, but lower fat and ash. Łozicki et al. (2017) recorded nearly similar

moisture (73.65±1.48), protein (21.87±0.64), ash (1.11±0.04) but lower fat (2.13±0.33) mean values for young beef (bull 1½ years old); and Elsharawy Nagwa et al. (2018) lower moisture and protein, but higher fat and ash. Gheisari et al. (2009) recorded lower moisture, and nearly similar protein, fat and ash in meat of young males and females Holstein cattle; while in olds recorded lower moisture, higher protein and fat, and nearly similar ash content.

Mammalian meat content (%) of glycogen is in the range of 0.5-1.3 with an average of 0.8% (FAO, 1992). The data obtained for carbohydrate content of the studied meats were mostly in complying with the previously mentioned range. As well, the gross energy mean values obtained for beef was in parallel with that of the FAO (1992), reported energy content for lean beef of 110Kcal/100g, which varied with the cut of the carcass.

Age of animals exerted no significant (P>0.05) effect for camel meat in relation to the studied items of chemical composition which disagree with a former study presented by Ahmed (2015), found significant (P<0.05) effect of age. In beef however, age significantly (P<0.05) affect the moisture (increase with age) and protein (decrease with age) content, but not affect (P>0.05) other items despite numerically changed (fat and energy decreased, while ash and carbohydrates increased with age). The obtained data partially support the findings of Gheisari et al. (2009) for camel and cattle meats, observed decrease in moisture and protein but increase in fat and nearly similar ash content with the increase of the animal age; and Kadim et al. (2016) for camel meat, recorded significant (P<0.05) decrease in protein and increase in fat, but non-significant (P>0.05) change (nearly similar means values) in moisture and ash content with the animal age. The data for camel meat however, disagree with the findings of Ahmed (2015) recorded significant (P<0.05) effect of age on chemical composition (decrease of moisture and protein, but increase in fat, ash, carbohydrates and energy contents with the age). Meanwhile, Kimassoum et al. (2016) mentioned that age variations had no significant (P>0.05) effect on chemical composition (moisture, protein, fat and ash) of camel *Longissimus dorsi* muscle which is in line with the present data. The effect of age is being through changes in muscle structure and composition, particularly the nature and quantity of connective tissue as animal matures (Asghar and Pearson, 1980).

The differences in values between studies could be attributed to differences in species, origin, feeding system and the muscle type evaluated (Paula and Ana, 2013; Abdelhadi et al., 2017). Cattle grazed on grass showed to have more muscle than those that received concentrate ration (Priolo et al., 2002). The variation between muscles might be due to location, activity, proportion of muscle fiber types, intramuscular fat and the ratio of water to protein of individual muscles (Kadim, 2013).

Storing beef frozen is commonly used in market issues. Taha et al. (2014) reported that freezing storage of meat causes only a small decrease in nutritive value and natural health promoting substances, which are largely retained with minute change. Aberle et al. (2001) however, declared that frozen meat can be negatively affected by storage time, beside freezing rate, and conditions of storage time. In the current study, for all age groups of both animal species freezing (-10ºC) up to 180 days leads to significant (p<0.05) decrease in moisture, but significant (p<0.05) increase in protein and gross energy values. The fat, ash, and carbohydrate values showed non-significant (p>0.05) changes (either increase or decrease). Biswas et al. (2014) recorded significant (p<0.05) decrease in moisture (75.98 to 70.58) and ash (1.49 to 1.42), but increase (p<0.05) in protein (24.95 to 25.64) and fat (5.5 to 6.0) for beef cuts stored at -20ºC for up to 9 months, which is in partial agreement with the results obtained. On the other hand, Aguiar (2017) found non-significant change of moisture, ash, and protein, but significant decrease of fat (from 5.66±0.4 to 2.11±0.32) in reindeer steer (2½ years old) *Longissimus dorsi* muscle stored frozen at -20ºC for up to 12 months, while Daszkiewicz et al. (2017) recorded that freezing at -26ºC for up to 10 months not influence (P>0.05) the proximate chemical composition (moisture, protein, fat, ash) of fallow deer *longissimus lumborum* muscle. The decrease in moisture content might be due to water loss (evaporation mainly) during freeze storage, while the increase in the values of some other constituents may be as the result of decrease in moisture content. Animal species (camel and cattle) in relation to age (young or old) significantly (P<0.05) affected the

change in chemical composition during freezing storage. The protein mean values was significantly changed, being lower (P<0.05) in young camel than in young cattle meat, while for old age being higher (P<0.05) in camel than in cattle meat, which might be attributed to variation in the rate of moisture loss from camel and cattle meats in relation to animal age. However, animal age (young and old) in relation to species (camel or cattle) showed no effect on the change of the basic chemical constituents during freezing storage, i.e. for camel meat, young and old ages still have nearly similar mean values (P>0.05) for each studied item. Likewise for cattle, meat samples of young animals still have significantly (P<0.05) lower moisture, but higher protein and energy; and nearly similar (P>0.05) fat, ash and carbohydrate contents compared to olds (Table 1).

The pH

The ultimate pH of meat has an effect on its color, appearance and keeping ability beside several other properties all of which influences the consumer acceptance (Lonergan et al., 2000; Kadim 2013). The living animals' muscle has a pH of 7.1, which is lowered after animal's slaughter to an extent depends on the glycogen store of the muscle prior to slaughter (Sebsibe, 2008). The decrease in pH value of meat is mostly attributed to the breakdown of glycogen with the formation of lactic acid, while the increase of pH with the storage may be due to the partial proteolysis leading to the increase of free alkaline groups (Pearson and Gillette, 1996).

The results in Table (2), showed an increase in the pH values of the fresh meat samples during chilling (4ºC) storage for all age groups. Such increase was non-significant (P>0.05) for young's meat, but significant (p<0.05) for olds either of camel or cattle. An opposite result was recorded by Abdelhadi et al. (2013), found decrease of pH value in *Longissimus thoracis* muscle of young (3-4 years old) female camel during chilling (1-3ºC) storage, from 5.72 at first day to 5.58 at 7th day. Bağdatli Aytunga and Kayaardi Semra (2015) however, recorded increase in pH of beef steak during chilling (4ºC) storage, from 5.57 at day1 to 5.7 at day 10.

The pH mean value for young age was higher (P>0.05) in camel than in cattle meat; however for old age it was lower (P<0.05) in camel than in cattle meat. The highest pH values was for old cattle (old cattle < old camel < young camel <young cattle) (Table 2). Kadim et al. (2008a) found nearly similar result of higher (P>0.05) pH value in young camel (5.89±1.34), than in young cattle (5.75±1.44 2) meat (*Longissimus thoracis* muscle). On the other side, Gheisari et al. (2009) recorded nearly opposite findings of lower (P>0.05) pH values in young camel meat than in young beef (male and female) and higher (P>0.05) values in old camel meat than in old beef (male and female). Eskandari et al (2013) in Iran found higher (P<0.05) pH values for meat (*Longissimus dorsi* and *Psoas major* muscles) of young (5.75-5.78) and old (5.4-5.43) camel (one-humped Iranian breed males) than for young (5.27-5.3) and old (5.22-5.23) cattle (Holstein bulls), respectively, which is partially support the current data. Edris et al. (2013) in Menofia, Egypt, estimated higher pH range for camel (5.53-5.84) than for cattle (5.46–5.78) meat from three different slaughterhouses. Pre-slaughter stress, post mortem treatments and muscle physiology are among the factors related to the difference in ultimate pH between the species (Babiker and Yousif, 1990; Kadim et al., 2008c; Yam et al., 2015). Laack *et al.* (2001) declared that 40-50% of variation in ultimate pH is determined by glycogen concentration. A high ultimate pH in muscles is a consequence of low muscle glycogen stores at the time of slaughter as a result of stress condition of bad management (poor nutrition, rough handling and long transportation) to which the animal subjected directly before slaughter (Kadim, 2013), beside the health condition of the animal. The high pH values of camel meat may beside lower muscle glycogen stores at the time of slaughter; be due to differences in muscle fiber types. Post-mortem metabolic rate differ related to fiber type being usually lower in muscles containing more slow oxidative fibers (Type I) than in muscles containing fast glycolytic fibers (Type II) (Karlsson et al. 1999; Lawrie and Ledward, 2006)). Soltanizadeh et al. (2008) and Abdelhadi et al. (2012) reported that post-slaughter pH decline of camel meat was significantly slower than that of beef as camel have different properties of their muscle fibers compared to bovine.

The mean values of pH, either the initial or by the end of the chilling (4ºC) storage life, was not differ (P>0.05) between young and olds camel meat samples despite numerically lower in young, while it was significantly (P<0.05) lower in young beef than in olds (Table 2). Gheisari et al. (2009) findings of lower pH values for young camels than for olds, but higher for young cattle than for olds, is partially support the current results; while the findings of Eskandari et al (2013), of higher (P<0.05) pH values for young than for old camel meat, and the non-significant (P>0.05) difference between young and old beef is in contrary to the current results. Opposite result was also recorded by Kadim et al. (2016), of lower (P<0.05) pH in olds than in young camels meat. The pH variation with the animal age may beside difference in glycogen store, be related to differentiation in muscle fiber types. Fiber types have been shown to differ at various stage of development with the increase in the proportion of fast twitch muscle fibers (Type II) as the animal mature, which may cause differ in patterns of muscle metabolism and ultimate muscle pH (Ashmore, et al., 1972, Swatland, 1982).

Kadim et al. (2016) estimated similar mean values of pH for young (5.95±0.14), but lower (5.75±0.14) for olds camel meat (*Longissimus thoracis* muscle). Abdelhadi et al. (2017) in Sudan estimated higher mean values in *Logissimus lumborum* muscle of young male (6.1±0.1) and female (6.15±0.11) camels; Kimassoum et al. (2016) in Chad, lower values in *Logissimus dorsi* muscle of old males (5.7) and females (5.86); Abdelhadi et al. (2013) in Sudan, lower value (5.72) in *Longissimus thoracis* muscle of young females; and Gheisari and Eskandari (2013) in Iran, higher mean value (6.49±0.16) in meat of old male camels (one humped Iranian breed), 24hrs post slaughter. As well, lower pH values were also recorded by Soltanizaheh et al. (2008), Kadim et al. (2009) "*Longissimus thoracis* muscle", Abou Youssef (2010), Kadim (2013), and Sayed (2018) "fore and hind quarters meat". Regarding beef, lower pH mean values were estimated by Taha et al. (2014) at Alexandria, Egypt, in fresh brisket meat, of 5.67±0.12, and Łozicki et al. (2017) in young beef (1½ years old bull), of 5.68±0.09; while nearly similar pH range of 5.7 - 6 by Alkhanky Sheryhan et al. (2015) in 2 years old male cattle *Biceps femoris* muscle, one day post slaughter. The differences in pH values between studies could be attributed to the muscle type evaluated (the cut); animal age; and the glycogen storage in the muscle at the time of slaughter (Paula and Ana, 2013). Kadim et al. (2013) declared that muscles in different parts of the carcass show a variation in the pH where the muscle position in the body affects its final pH.

The meat samples storage life at chilling (4ºC) on the base of organoleptic changes (loss of color, slimy, emit off odor) was found to be about 8 days for young camel, 7days for young cattle meats; 10 days for old camel, 6 days for old cattle. Fallah et al. (2008) estimated refrigerated (4-7ºC) storage life of 7 days for camel meat, while Sedeh et al. (2007) estimated 3 days for beef. Bağdatli Aytunga and Kayaardi Semra (2015) recorded storage life of 25 days for beef steaks stored at 4ºC.

Lipid peroxidation:

Meat lipid peroxidation is one of the main factors limiting the quality and acceptability of fresh meat and meat products during storage at both refrigeration and freezing temperatures. It had negative impact on the aroma, color, flavor, nutritive value of meat and on health of consumer (Jakobsen and Bertelsen 2000; Alderton et al., 2003; Li and Liu 2012). The extent of lipid peroxidation in meat varied with the carcass cut, muscle type and animal species (Rhee et al., 1996; Rhee and Ziprin, 2002). Other factors affect meat lipid peroxidation includes the presence of anti- and pro-oxidants and abundance of unsaturated fatty acids (Jakobsen and Bertelsen, 2000). The TBA value (mg malonaldehyde/kg meat) best referred to as TBARS, is routinely used as index of lipid peroxidation in meat and its products (Habbal, 2000) at storage. The TBA number of a sample shows a steady increase as it becomes more rancid (Tokur et al., 2006).

The results in Table (3) and Figure (1) evidenced that meat samples for all ages showed a steady increase in TBA values (lipid peroxidation) during chilling (4ºC) storage. Such increase was significant (P<0.05) in young camel meat but highly significant (P<0.01) in young beef. For olds the increase was significant (P<0.05) in camel meat but insignificant (P>0.05) in beef. Similar results of increase in TBA value during chilling storage of meat were recorded by Gheisari (2011), found

significant (P<0.05) increase, from 0.072 to 0.317 for one-humped Iranian breed camel, and from 0.043 to 0.239 for Holstein cattle, during 4 days storage (4ºC) of *Longissimus dorsi* muscle obtained from mature animals 3 days postmortem. Gheisari and Eskandari (2013) recorded an increase (p<0.05) of TBA mean value (µmol/kg) during 12 days storage (4ºC) of fresh male camel meat, from 0.03±0.02 "24hrs post slaughter" to 0.49±0.36 at day 8 and up to 0.71±0.21 at day 12; and Sayed (2018), an increase during storage of fore and hind quarters camel meat at 4ºC for a week, from 0.28 mg/kg at day 1 up to 0.81 at day 6. Non-significant (P>0.05) increase of MDA content (µg/g) in *Longissimus thoracis* muscle of young she-camel was recorded by Abdelhadi et al. (2013) during chilling (1-3ºC) storage of up to 7 days . The results of meat lipid peroxidation in young beef at chilling storage supports the findings of Popova et al. (2009), detected significant increase of MDA (mg/kg) in meat of 2 years old bull during storage (4ºC), from 0.17 at day 1 to 0.32 at day 6, however Łozicki et al. (2017) estimated non-significant increase of TBA value (nmol/g) in young bull meat during 7 days of chilling storage, which not matches the current results. Bağdatli Aytunga and Kayaardi Semra (2015) recorded an increase during storage (4ºC) of beef steaks, from initial value of 0.142 at day 1 to 0.26 at day 10 and up to 0.81 at day 35. Durand et al. (2006) and Durand et al. (2007) found no difference (P>0.05) in MDA levels among aging days for Charolais cull cows aged for 5 and 12 days, respectively, which goes in line with the present findings for old beef. Meat lipid peroxidation was noticed to have low intensity as the contents of TBARS in the course of storage remained below the threshold for detection of rancid odor; however it was higher in the young beef than in other meat samples. Habbal (2000) declared that the rancid flavor is initially detected in meat when TBA values lies between 0.5 and 2.0 mg/kg, while Wong et al. (1995) declared that rancidity was detected at TBA value of 3mg/kg.

The rate of meat lipid peroxidation during chilling storage was generally noticed to be lower in camel meat than in beef, i.e. camel meat either from young or olds need more days to attain the same TBA value recorded in beef. This may be attributed to the content of vitamin E in camel meat, which considered controlling meat lipid peroxidation during storage. Vitamin E (α-tocopherol) is an important lipid soluble antioxidant reacting with and removes the free radical intermediates produced in the lipid peroxidation chain reaction, thus prevent the oxidation reaction from continuing (Herrera and Barbas, 2001; Traber and Atkinson, 2007). Abdelhadi et al (2013) found that vitamin E content in camel meat was three folds higher (17.8 µg/ g) than that (5 µg/ g) reported by Durand et al. (2007) in *Longissimus thoracis* muscle of cows fed with plant extracts combined with vitamin E. No significant effect of aging on vitamin E content of camel meat was found (Abdelhadi et al., 2013). Gheisari (2011) recorded higher rate of lipid peroxidation in camel meat than in beef, which disagree the current results. Abdelhadi et al. (2013), estimated lower rate of TBA increase in *Longissimus thoracis* muscle of young she-camel; while Gheisari and Eskandari (2013) estimated higher rate in *Longissimus dorsi* muscle of old male camels; and Sayed (2018), higher rate in camel meat of fore and hind quarters. On the other hand, Popova et al. (2009) and Bağdatli Aytunga and Kayaardi Semra (2015) estimated lower rate of TBA increase in young beef and beef steaks, respectively.

The initial (day zero) TBA mean value was higher in young camel meat than in young beef; however it was nearly the same for old camel meat and beef. By the end of chilling storage life, TBA mean value of 0.472±0.132 was attained in young camel meat "day 8", while in young beef the highest TBA mean value (0.784±0.189) was estimated "day 7". In old camel meat TBA mean value of 0.554±0.088 was attained "day 10"; and the lowest value (0.384±0.064) was in old beef "day 6". Abdelhadi et al. (2013) supposed that ageing meat contained high levels of intramuscular fat longer than 7 days is of high risk. The varying rate of lipid peroxidation in different age groups could might related to the raising mode of the studied animals (Yang et al., 2002). Raising on pasture increased significantly the content of natural antioxidants in muscles, such as vitamin E, carotenoids, etc. (Gatellier et al., 2005) and hence reduces the development of meat lipid peroxidation. Fattened young cattle usually raised on more concentrate diet, but camels and old cattle usually get admit to more pasture feed. The low TBA value in old beef samples could be, besides raising mode, attributed to their high pH values. Witte et al. (1970) found that TBA and pH values in cold (4ºC) stored beef were

inversely related i.e. the increase in pH value is accompanied by decrease in TBA value. Gheisari (2011) found higher values of TBA (µmol/kg) in mature camel meat (0.204) than in mature beef (0.131) which not comply with the current findings for old ages. Edris et al. (2013), however, recorded higher values in fresh beef than in camel meat obtained from 3 different slaughterhouses at Menofia, Egypt. The recorded TBA values in fresh camel (0.01-0.21) and cattle (0.02-0.27) meats were lower than the current. Lower values were also found by Abou-Youssef (2010) in fore and hind quarters camel meat; Abdelhadi et al. (2013) in *Longissimus thoracis* muscle of young she-male camels; Gheisari and Eskandari (2013) in *Longissimus dorsi* muscle of old male camels, while higher values by Sayed (2018), of 0.28±0.03 and 0.27±0.04 in fore and hind quarters camel meat, respectively. For cattle meat, Popova et al. (2009) and Łozicki et al. (2017) detected higher initial TBA mean values in young beef; Taha et al. (2014) higher mean value in fresh brisket meat, while Bağdatli Aytunga and Kayaardi Semra (2015) detected nearly similar mean value in beef steaks. Lower values were recorded by Botsoglou et al. (1994) in cow muscle (0.138); and Okolie and Okugbo (2013) in lean beef (0.13±0.04).

It was noticed that by the end of the chilling storage life, TBA mean values for all samples not exceeded the permissible limit of 0.9 mg/kg set by the Egyptian standards (ES, 2013) for fresh chilled meat. Similar result was recorded by Abdelhadi et al. (2013) and Sayed (2018) for camel meat stored at chilling for up to a week. Likewise, Popova et al. (2009) and Łozicki et al. (2017) found similar result for beef stored at chilling for up to 7 days.

Storing meat at freezing causes minute decrease in nutritive value (Taha et al, 2014). Studies, however, have shown that freezing storage of meat leads to time dependent accumulation of lipid peroxidation products of public health concern, mainly malondialdhyde (Rey et al., 2001; Wills et al., 2004). In the present study, freezing storage (-10ºC) up to 180 days of camel and cattle meat samples of different age groups showed time dependent increase in the TBA value (meat lipid peroxidation) which support the previous findings. Widayaka et al. (2001), Taha et al. (2014), Al-Sabagh Eman et al. (2016), and Cho et al. (2017) found significant increase ($P<0.05$) in TBA values during frozen storage of beef. Aguiar (2017), however recorded decrease (from 0.65±0.03 to 0.50±0.08) in TBARS during 6 months freezing (-20ºC) storage of reindeer steers meat, but significant ($p< 0.05$) increase to 1.50±0.16 mg/kg during 12 months storage.

By the end of the freezing storage period the increase in TBA values was highly significant ($P<0.01$). The meat lipid peroxidation was the highest in young beef, while it was the lowest in old camel meat (young beef > old beef > young camel meat > old camel meat) as declared in Table (4) and Figure (2). Higher values of increase in TBA (mg/kg) was estimated by Widayaka et al. (2001) during freezing (-18ºC) storage of beef, from 0.5 "day 0", to 1.0 "week 8", and up to 1.8 "week 12"; and Taha et al. (2014) during freezing (-20ºC) storage of cattle brisket meat, from 3.0 ± 0.38 (fresh meat), to 3.68 ± 0.4 (1 month at -20ºC), and up to 5.65± 0.03 (2 months at -20ºC). Taha et al. (2014) declared that the high recorded values of TBA in brisket meat may be due to the nature of the samples (fatty meat), however, the pH values of such samples remained within the normal accepted range (5.53 – 5.73), and rancidity was not developed during storage of the meat within two months. Okolie and Okugbo (2013) in Nigeria found higher increase ($P<0.05$) of the TBA value in beef stored frozen (-10ºC) for 5 days; and Al-Sabagh Eman et al. (2016) in Egypt, higher increase in cattle meat stored frozen (-7°C) for 1 month. On the other hand, Popova et al. (2009) detected lower increase in TBA value in young beef (2 years old bull) stored frozen (-20ºC) for 90 days after being chilled for 6 days, from 0.32 to 0.64 mg/kg; and Cho et al. (2017) lower increase in beef (Hanwoo steers) stored at freezing (-18ºC) for 9 months after 14 days aging at 2ºC, from 0.75 to 0.82 mg/kg.

The TBA mean values in the present study was noticed to be still below the limit (0.9 mg/kg) set by the Egyptian standards (ES, 2005) for frozen meat, up to 120 days (4 months) in young camel meat, and only up to 90 days (3 months) in young beef. In old camel meat the values still below the limit up to 120 days (4 months), while in old beef only up to 60 days (2 months) of freezing (-10ºC) storage. Longer period of storage at freezing with TBA values within the limit were recorded by

Aguiar et al. (2017) (6 months at -20ºC), and Cho et al. (2107) (9 months at -18ºC) for young beef; while shorter periods by Widayaka et al. (2001), and Okolie and Okugbo (2013). Nearly similar period of storage in young beef (90 days at -20ºC) was found by Popova et al. (2009).

Malondialdehyde is classified as perhaps the most abundant cytotoxin arising from lipid peroxidation in muscle derived foods, especially meat (Stocker and Keaney, 2005; Gorelik et al., 2007). It is readily absorbed from ingested food in the form of N-(2-propenal)-lysine (Gopaul et al., 2000), where it forms adducts with deoxyadenosine and deoxyguanosine, causing DNA damage that may pose serious health problems to the consumers (West and Marnett , 2005).

Taken together, dromedary meat is preferred over other meat animal species believed to have remedial effects for many different life-style related diseases as hypertension beside its availability at affordable prices that permit access to high quality animal protein for the most disfavored populations often (Kadim, 2013; Kimassoum et al., 2016). In addition, high levels of vitamin E in camel meat compared to bovine would help to decrease the rate of meat lipid peroxidation and increase shelf life of camel meat products **(**Abdelhadi et al., 2013). Human consumption of camel meat should lead to a reduction in total fat intake and an increase in polyunsaturated fat as compared with other conventional red meat sources. Camel meat also contains less cholesterol than beef or lamb, which suggests that it is healthier (Kadim et al., 2008b).

CONCLUSION

From the obtained results it could be assumed that camel meat is nutritionally comparable to beef of the same age category, even though it has an edge being lower in intramuscular fat content. Animal age showed an effect on the basic chemical composition in cattle but not in camel. The pH changes during chilling storage were affected by animal age but not the animal species. Meat lipid peroxidation during cold (chilling or freezing) storage was affected by animal species and to less extent by animal age. The lipid peroxidation rate during chilling and freezing storage is being lower in camel meat than in beef. The cold storage (chilling or freezing) life of camel meat was longer than that of cattle meat. Camel meat can be stored at 4ºC for up to 10 days while that of cattle not more than 7 days. Camel meat can be safely stored up to 4 months at -10ºC but cattle meat better not more than 2 months. Camel meat consumption recommended to be encouraged in the community in Egypt through scientific research beside different media channels, representing a viable alternative to beef from nutritional, health and economical points of view. The dromedary camel meat can be successfully marked alongside of other red meats.

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