j.Egypt.vet.med.Assoc 77, no 1. 33 – 46 (2017)

EFFECTOF INCORPORATINGFATS OF DIFFERENT ANIMALSPECIES ON PROXIMATE CHEMICAL ANALYSIS, COOKING CHARACTERISTICS AND DETERIORATIONCRITERIAOF BEEFFRESH SAUSAGES

By

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ABSTRACT

Fat has an important role in the processed of meat products. Therefore, the current study was designed to evaluate the effect of incorporating fats from different food animals [beef (mesenteric and perinephric), buffalo (mesenteric and perinephric), Camel (mesenteric and hump) and mutton (mesenteric and perinephric) on Proximate chemical analysis (Moisture%, protein%, fat%), Cooking characteristics (cooking loss%, diameter reduction%, moisture retention% and fat retention%) and Deterioration criteria (pH, Thiobarbituric acid reactive substance "TBARS" and Total volatile basic nitrogen "TVBN") of fresh sausages. Higher cooking loss% values were recorded when fresh sausages processed using either buffalo perinephric or camel hump fats compared with those processed using beef or mutton fats. The highest level of diameter reduction% was obtained when camel hump fat was incorporated followed by buffalo perinephric fat incorporation. TBARS of fresh sausages formulated using beef perinephric fat revealed the lowest values when compared with other formulae. Based on this study, Buffalo perinephric and camel hump fats are not recommended for production of high quality acceptable fresh sausages in contrary to beef and sheep tallow.

Keywords:

Cooking loss, TBARS, pH, TVBN, fresh sausage, animal fat.

INTRODUCTION

Changing the consumer's life style led to increase the consumption of sausages as fast food. Fresh sausage is one of the most popular processed meat products Especially in Egypt. It is made using a combination of raw ingredients which yield a final product of acceptable quality at a competitive price **(Ali, *et al*. 2010)**. Duo to its unique characteristics, Sausages represent a cheap delicious meat product and are gaining popularity all over the world, as it represents a quick easily prepared meals and solve the problems of shortage in fresh meat **(Hassan and**

Daoud, 1997). Sausage production is a simple process where meat undergoes series of structural and chemical changes which are nearly the same to all cultures while, only varies in the method of preparation and spice components to achieve desired distinctive organoleptic characteristics. Sausage production represent an advantage to the manufacturers where, it normally utilizes meat trimmings which are relatively cheap as a raw material and are basically characterized by a high fat content and connective tissue with low functionality. Therefore, sausage manufacture is considered a mean of adding value to these low value cuts and increasing the utilization of carcass meat. Sausage manufacture is an art that has been practiced for centuries all over the world, probably starting as soon as people learned that salt is an effective preservative and considered the oldest forms of processed meat products. Nowadays, more than 250 type of sausage are sold, a lot of them named after the town and/or country of origin. **(Essien, 2003; Dinstel, 2014)**. Fresh sausages are coarsely comminuted, not heat treated products that are sold as uncooked, fresh (chilled) or frozen. It is a mixture of meats, fat and spices stuffed into casings mainly natural casing of animal small intestine. The lean portion can be made from edible red meat, poultry or both of them, while the fat portion is generally solid fat material such as animal fat tissue while liquid fat material, such as oil, is not utilized **(Feiner, 2006)**. One of the basic, most important characteristic of fresh sausages is the distinctive marbling appearance between lean and fatty portions that can be achieved by using animal fat which is a distinctive criterion in this product. Fat is considered one of the most variable raw materials in sausage products, as it represents a large percentage of sausage composition which may reach up to 30% and is important in the processing, textural, juiciness and sensory criteria of sausage products **(Baer and Dilger, 2014)**. Characteristics of animal fat differ between animals according to type of feeding ration, species or even their anatomical location within the same animal **(Wood *et al.,* 2008)**. The difference in the characteristics of fats between different animals and cuts within the animal may affect the characteristics of fresh sausages processed with fats from different animal species and different cuts within the animals. Moreover, cooking has a major effect on adipose tissue. Far to our knowledge studies on the comparison of characteristics of fresh sausages processed with fats from different animal species and different cuts within the animal are rare. Therefore, the main objective of the current study was to evaluate the effect of incorporation of food animal fats from different species and different anatomical locations on proximate chemical composition, deterioration criteria (pH, Total volatile basic nitrogen

(TVBN) and thiobarbituric acid reactive substances (TBARS) and Cooking characteristics of oriental beef fresh sausage for 3 months of frozen storage.

MATERIAL AND METHODS

Experimental design:

Eight Treatments based experiment with three independent replicates was performed to compare the proximate chemical analysis (moisture%, protein%, fat% and ash %), cooking characteristics (Cooking loss %, Moisture retention% and fat retention%) and deterioration criteria {pH, thiobarbituric acid reactive substances (TBARS) and total volatile base nitrogen (TVBN)} of oriental beef fresh sausages processed with fats obtained from different food animals and different locations. Fats were obtained from beef (mesenteric and perinephric), buffalo (mesenteric and perinephric). Camel (mesenteric and hump) and mutton (mesenteric and perinephric).

Preparation of sausages ingredients:

Five imported deep frozen beef chucks (fore quarter cut - shoulder Minerva S. A., Tocantins, Brazil) were obtained from a local store within the first third of their shelf life. Meat chucks were stored at -18 °C until use. Fats from different animals and different locations as well as sheep round "small intestine" casing were obtained from a slaughterhouse (Cairo, Egypt) immediately after slaughter then rapidly transported in ice box to the laboratory. They were wrapped in polyethylene bags and stored at -18°C till processing. Sodium tripolyphosphate, sodium nitrite and seasonings mix were obtained from Loba Chemie, Mumbai, India. Moreover, the sodium chloride and starch were obtained from a local market at Cairo, Egypt.

Product formulations:

A base batter was formulated by using a simple traditional formulation as follows: 62 % lean beef meat, 18 % fat, 1.6 % sodium chloride, 13 % water, 5 % bread crump, 0.3 % sodium tripolyphosphate, 100 ppm sodium nitrite and 0.05 % seasonings mix. Eight formulas were prepared from the base batter by using beef mesenteric fat and beef perinephric fat for the 1st and 2nd formulas, buffalo mesenteric fat and buffalo perinephric fat for the 3rd and 4th formulas, camel mesenteric fat and camel hump fat for the 5th and 6th formulas, meanwhile, mutton mesenteric fat and mutton perinephric fat were added to the 7th and 8th formulas.

Sausage processing:

Three independent replicates for each sausage treatment were processed. For each replicate, the frozen beef of each formula was tempered to - 5 ºC, flanked by using meat saw

(Italians, Italy) and trimmed of all visible fat. The trimmed lean beef and fat of each formula were ground through a 4.5-mm plate grinder (Seydelmann NW 114 E;Stuttgart, Deutschland, Germany). The ground lean beef and fat of each formula were mixed together with water, salt, bread crump, sodium nitrites, polyphosphates and seasonings for 5 minutes. The mixture of each formula was then stuffed into 18 Ø mm natural sheep casing using piston filler and linked to approximately 10-12 cm length then placed in plastic containers, held at - 40 ºC for 30 min and then stored at-18 °C. For each replicate, samples were withdrawn from each formula for analysis at 2nd day for further investigations.

Fresh sausage analysis

Proximate chemical analysis (AOAC, 2000):

Oriental sausage representing each sample was rendered into uniform mass by mixing thoroughly using mortar. Moisture, protein, fat and ash contents of Oriental beef fresh sausage from different treatments were determined for each replicate after the processing according to the method of **AOAC (2000)**. For determination of moisture contents (g % sample), 10 g of sample were dried at 100 °C for 16-18 hours until two constant weights was obtained. Protein content (g % sample) was determined according to the Kjeldahl method of analysis. For conversion of nitrogen into crude protein, a factor 6.25 was used. Fat (g % sample) was determined by cycle extraction with petroleum ether in a soxhlet apparatus and calculating the weight loss. Ash was determined by ignition at 500 °C for 5 h (g % sample).

Cooking characteristics (Cooking loss%, Moisture retention% and fat retention%).

From each replicate individual cylindrical fresh sausage fingers were placed in aluminum plates and wrapped with aluminum foil. Cooking was performed in a convection oven (Heraeus, D-63450 Hanau, Germany) adjusted at 180 °C to an internal temperature 75 °C and the cooking temperature was monitored by a needle thermocouple probe attached to a previously calibrated hand-held thermometer (Hanna HI 985091-1; Pasadena, TX, USA). Cooking loss was calculated as outlined by **Neel *et al.* (1987)**. The samples were weighed accurately just before cooking. After cooking, the samples were cooled and weighed immediately. The cooking loss as a percentage was the difference in weights of the sample before and after cooking. Moisture retention value represents the amount of moisture retained in the cooked product/ 100 g sample. The percentage of moisture retention was calculated according to the equation of **El-Magoli *et al.* (1996)** as following:

$$\text{Moisture retention\%} = \frac{\text{Cooking yeild} \times \text{moisture percentage in cooked sample}}{100}$$

Meanwhile fat retention value represents the amount of fat retained in the cooked product/100 g raw sample. The percentage of fat retention was calculated according to **Murphy *et al.* (1975)** as following:

$$\text{Fat retention \%} = \frac{\text{Cooked weight} \times \text{fat percent in cooked samples}}{\text{Raw weight} \times \text{fat percent in raw samples}} \times 100$$

Deterioration criteria {pH, thiobarbituric acid reactive substances (TBARS) and total volatile base nitrogen (TVBN)}.

The pH, TVBN and TBARS (raw and after cooking) values were determined after processing and monthly during storage for 3 months. For measurement of pH value, five grams from each of the sausage samples was homogenized with 20 ml distilled water for 10-15 s **(Kandeepan *et al.*, 2009)**. The pH was measured using a pH meter (Lovibond Senso Direct) with a probe type electrode (Senso Direct Type 330) where three reading for each sample was obtained and the average was calculated. The meter was calibrated every two samples using two buffers 7.0 and 4.0. The thiobarbituric acid reactive substances (TBARS) value was measured by the method outlined by **Du and Ahn (2002)** for both raw and cooked samples and expressed as milligrams of malondialdehyde per kilogram of sample. Moreover, the Total Volatile Base Nitrogen (TVBN, mg/100 g sample) was measured according to the method of **Kearsley *et al.* (1983)** using a macro-Kjeldahl distillation method.

Statistical analysis:

Results for different parameters were reported as mean values. Analysis of variance was performed by ANOVA procedure using SPSS 17.0 for windows. Differences between the Mean values ± standard deviation (SD) were determined by least square difference test (LSD) procedure. Main effects were considered significance at $P<0.05$.

RESULTS AND DISCUSSION

Proximate chemical composition of beef fresh sausage formulated using fat of different animals.

Results in (Table 1) revealed that ash percentage and fat percentage values had no significant ($p<0.05$) difference among the eight oriental beef fresh sausage treatments, However the obtained values of protein percentage ranged from 14.54% to 14% whereas highest significant ($p<0.05$) values was from sausage formulated using hump fat (14.54%) and nearly all the

treatments readings was around this percentage with the lowest value of 14% obtained using sheep mesenteric fat. Meanwhile,the moisture percentage ranged from 65.53% as a maximum value when buffalo mesenteric fat was incorporated to 64.24% as a minimum value when camel hump fat was used and generally speaking the difference between treatments was not significant ($p<0.05$). the obtained results agree with the general manufacturing practices (GMPs) for fresh sausage production determined by **Essien (2003)** and comes in agreement with Egyptian standard specifications **ESS 1975-2005** which determine the moisture percentage (around 60%), protein percentage (around 15%), fat percentage (around 30 %) and ash percentage (around 5%). Although several authors reported a wide variation in the chemical analysis of market fresh sausage surveys as **Abd EI-Gawwad *et al.* (1986)** who examined Sausage samples were obtained randomly from butchers in different districts in Mansoura and found that chemical composition of the sausages was: 55 - 89 % moisture, 12.89 - 35.72 % protein, 55.52 - 84.25 % fats, 1.60 - 6.47 % carbohydrates and 1.25 - 10.37 % ash. Also **Hamed *et al.* (1993)** reported that examined Fresh Egyptian sausage samples from different governments contained:33.88-47.42% moisture;32.88-46.06%protein; 47.62 - 59.88 fat; 2.46 - 4.97% ash. Moreover, **Edris *et al.* (2012)** collected and examined 25 sample of beef fresh sausage and found that mean values of moisture, protein and fat were 62.98% ± 0.19, 10.37% ± 0.20 and 24.61% ± 0.26, respectively. Such a high degree of variabl1ity in chemical composition could be attributed to the wide variation in raw materials used in sausage manufacture especially when filler i.e. starch or bread crumbs as well as plant soya protein is incorporated in fresh sausage formulations.

Cookingcharacteristics of beef fresh sausageformulated using fat ofdifferentfood animals.

Results in (Table 2) revealed that cooking characteristics varied widely among the different sausage treatments. Cooking loss (shrinkage %) minimum significant ($p<0.05$) value of sausage treatments. Cooking loss (shrinkage %) minimum significant ($p<0.05$) value of 14.21% was recorded when sheep mesenteric fat was used, however, the highest significant ($p<0.05$) value of 32.75% when buffalo perinephric fat was incorporated into sausage followed by 25.28% when camel hump fat was used it was noticed that, the last two treatments had also the highest significant ($p<0.05$) diameter reduction percentage of 18.31% and 19.26% which could be explained either duo to moister loss or fat loss or both of them. Regarding sausage formulated using buffalo perinephric fat the cooking loss was due to both moisture and fat loss which can be clearly concluded from the results of moisture and fat

retention as this treatment was the lowest significant ($p<0.05$) treatment which retained either moisture or fat 42.67%, 42.77% respectively, among the other sausage treatments. Meanwhile, the cooking loss in sausage formulated using camel hump fat owed to loss of fat rather than moisture loss which was concluded from the results of moisture retention (45.97%) and fat retention (55.75%) of this treatment. Cooking loss of sausages formulated using beef fat or buffalo mesenteric fat did not significantly ($p<0.05$) differ ≈ 20% and results showed that loss was due to both moister and fat loss while cooking loss of sausage formulated using sheep fats was low due to high percentage of retained moisture and fat as showed in (Table 2). Generally, the high average of cooking loss for all treatments may be regarded to the method of cooking which was in convection draught oven not in frying oil or boiling as these methods may interfere the effect of different fat type although **Abd EI-Gawwad *et al.* (1986)** recorded different higher values of cooking loss for market fresh sausage ranged between 45.56 % and 52.75%. also **Abd El-Naeem (2010)** found that among the market fresh poultry sausage the cooking loss was 30.11%, moisture retention was 40.8%, fat retention was 60.57% diameter reduction was 18.47%.Menwhile,**Hussein(2003)**examinedmarket orientalcamel fresh sausage samples and found that cooking loss values was min. 30%, max.45.2% with mean ± SE of 38.15% ± 0.56. Moreover, **Ambrosiadisa *et al.* (2004)** evaluated Greek traditional sausages with is similar in processing and formulation to oriental Egyptian fresh sausage and found that mean value ± SD of cooking loss was 12.81% ± 5.27 with min. 0.9%, max. 30%.

Deteriorationcriteria of beef fresh sausage formulated using fat of different food animals.

pH Results in (Table 3) showed that values in 0-time ranged from 5.53 to 5.61.The maximum recorded value was from sausages formulated using mesenteric fat of either beef or buffalo (5.61) .Sausages formulated using beef fat, buffalo mesenteric fat and camel mesenteric fat had significantly ($p<0.05$) higher values than all the other treatments. Meanwhile, frozen storage significantly ($p<0.05$) increased the pH values by the end of the 3rd month the highest recorded significant ($p<0.05$) value was obtained from sausage processed using buffalo perinephric fat (6.38), However, this maximum pH value did not exceed the maximum limit i.e. 6.4 for frozen meat **ESS 2005/1522**. The obtained results come in a good agreement with **Hamed *et al.* (1993)** who found that pH of fresh sausage market samples fluctuated between 5.2- 6.9. Moreover, **Hussein (2003)** reported a mean ± SE value of 6.7 ± 0.01 among examined market oriental camel fresh sausage samples. Meanwhile, **Abdelkader *et al.* (2017**) examined 15 samples of beef fresh sausage in Bab El-Louk market, Cairo, Egypt and found that mean ±

SD value of pH was 5.927 ± 0.171. TVBN (mg/100g sample) results in (Table 3) showed that values in 0-time ranged from 5.60 to 6.25, the highest significant ($p<0.05$) value was recorded from sausages formulated using buffalo perinephric fat. Although, frozen storage significantly ($p<0.05$) increased the pH values by the end of the 3rd month while the highest recorded significant ($p<0.05$) value was 7.28 mg/100g which obtained from sausage processed using sheep perinephric fat. Generally, those values are below the maximum limit provided by Egyptian standard specifications of frozen oriental sausage **ESS 1975-2005** which was 20mg/100g sample. Many authors investigated TVBN in fresh sausage and reported such low values as **Hussein (2003) and Abd El-Naeem (2010)** who reported mean values of 9.8 and 10.6 respectively. Also many authors reported such higher values as **Mohammed (2002)**, **Awad (2003), Abd El-Ghafar (2005) and Abd-el-Kader *et al.* (2017**) who reported mean values of 20.1, 15.2, 22.88 and 19.820 and Respectively. Moreover, **Ali *et al.* (2010)** reported that mean TVBN of the investigated fresh sausage at 0-time 9.8 and increased by 12 day chilled storage reaching 19.8 mg/100g sample. Fat oxidation of fresh sausages processed using different animal fats was investigated using TBARS test has been used as a good indicator for lipid oxidation in meat and meat products that measures the oxidation products (malonaldehyde) **(Wood *et al.,* 2008)**. Results of 0-time in (Table 3) revealed that TBARS of fresh sausages formulated using beef mesenteric or buffalo mesenteric fat had the highest significant ($P<0.05$) values, however, fresh sausage formulated using beef perinephric fat showed the lowest significant ($P<0.05$) value. Cooking resulted in significant ($P<0.05$) elevation of TBARS in all fresh sausages formulae. The highest values for TBARS were observed in sausages formulated using sheep perinephric fat and the lowest values were recorded for fresh sausages formulated using beef mesenteric fats. Moreover, the results revealed that all values for TBARS were in good agreement with the critical limits established by previous authors for different animal species **(Campo *et al.,* 2006; Greene and Cumuze, 1981; Tarladgis *et al.,* 1960)** for lipid oxidation products that produce a detectable rancid odor and test by consumers. The obtained results showed that, the highest significant ($P<0.05$) mean value after 3 months of frozen storage was (0.411 mg/kg) which obtained from fresh beef sausage formulated using sheep mesenteric fat while, after cooking the highest significant ($P<0.05$) raw TBARS mean value was (0.541 mg/kg) which obtained from sausage formulated using of buffalo perinephric fat. The unexpected good notice was that even after cooking the maximum lipid oxidation measured using TBARS did not exceed the

permissible limit for raw oriental frozen sausage ESS 1975-2005. Many authors reported higher degree of lipid oxidation as **Hussein (2003)**,**Gab-Allah and Shalaby (2001)**, **Abdelkader *et al.* (2017) and Mohammed (2002)** who reported mean TBARS values of 0.6, 0.66 , 0.681 and 0.87, Respectively although many other authors reported results agrees with our findings as **Abd El-Ghafar (2005)** 0.15, **Abd El-Naeem (2010),Helmy (2007), Awad (2003) and Ali (2010)** who reported mean TBARS values of 0.54,0.29,0.31 and 0.23,respectively Moreover, After frozen storage for 3 months **Helmy (2007), Awad (2003)** reported mean TBARS values of 0.44 and 3.7, respectively while, **Ali (2010)** reported increased TBARS values to 0.74 after 12 day chilled storage.

CONCLUSION

It was concluded from this study that, fresh sausages formulated with fats from buffalo or camel revealed a higher cooking loss% when compared with those formulated with other fats. Moreover, the highest cooking loss was recorded for sausages formulated using perinephric fat of buffalo. The highest level of TBARS was obtained when mesenteric fat of beef or buffalo was used while the lowest level was recorded when using beef perinephric fat was used. Therefore, Buffalo perinephric and camel hump fats are not recommended for production of high quality acceptable fresh sausages in contrary to beef and sheep tallow.

Table (1): Proximate chemical composition (%) of beef fresh sausage formulated using fat of different food animals.

		Moisture	Protein	Fat	Ash
Beef	**Mesenteric fat**	**64.74 ± 0.43^{a,b,c*}**	**14.29 ±0.26^{a,b,c}**	**17.67 ± 0.59^{a}**	**2.01 ± 0.15^{a}**
	Perinephric fat	**64.88 ± 0.68^{a,b,c}**	**14.44 ± 0.09^{a,c}**	**17.35 ± 1.52^{a}**	**2.29 ± 0.19^{a}**
Buffalo	**Mesenteric fat**	**65.53 ± 0.84^{b}**	**14.04 ± 0.09^{b}**	**17.46 ± 0.50^{a}**	**2.02 ± 0.05^{a}**
	Perinephric fat	**65.12 ± 0.65^{a,b,c}**	**14.21 ± 0.21^{a,b}**	**17.72 ± 0.68^{a}**	**2.02 ± 0.31^{a}**
Camel	**Mesenteric fat**	**64.53 ± 0.25^{a,b,c}**	**14.30 ±0.28^{a,b,c}**	**17.41 ± 1.37^{a}**	**2.25 ± 0.15^{a}**
	Hump fat	**64.24 ± 0.34^{c}**	**14.54 ± 0.07^{c}**	**17.70 ± 0.58^{a}**	**2.37 ± 0.42^{a}**
Sheep	**Mesenteric fat**	**65.52 ± 0.82^{b}**	**14.00 ± 0.03^{b}**	**16.79 ± 0.67^{a}**	**2.22 ± 0.36^{a}**
	Perinephric fat	**64.41 ± 0.94^{a,b,c}**	**14.13 ± 0.20^{b}**	**17.83 ± 1.66^{a}**	**2.31 ± 0.19^{a}**

***Data represent the mean of three independent replicates ± SD, $^{a-c}$Values with different superscripts within the same column for all treatments are significantly ($P < 0.05$) different.**

Table (2): Cooking characteristics (%) of beef fresh sausage formulated using fat of different food animals.

		Cooking yield	Cooking loss	Diameter Reduction	Moisture Retention	Fat Retention
Beef	**Mesenteric fat**	**79.08 ± 0.84^{a}***	**20.92 ± 0.84^{a}**	**14.15 ± 0.23^{a}**	**51.78 ± 0.96^{a}**	**60.81 ± 1.06^{a,b}**
	Perinephric fat	**79.23 ± 0.79^{a}**	**20.77 ± 0.79^{a}**	**14.03 ± 0.27^{a,b}**	**51.63 ± 0.44^{a}**	**60.48 ± 1.22^{a,b}**
Buffalo	**Mesenteric fat**	**80.03 ± 0.84^{a}**	**19.97 ± 0.84^{a}**	**13.59 ± 0.61^{a,b}**	**49.74 ± 0.47^{b}**	**73.88 ± 0.46^{a,d}**
	Perinephric fat	**67.25 ± 0.91^{b}**	**32.75 ± 0.91^{b}**	**18.31 ± 0.45^{c}**	**42.67 ± 0.84^{c}**	**42.77 ± 0.44^{c}**
Camel	**Mesenteric fat**	**84.44 ± 0.14^{c}**	**15.56 ± 0.14^{c}**	**13.49 ± 0.48^{a,b}**	**57.09 ± 0.58^{d}**	**48.81 ± 0.30^{b,c}**
	Hump fat	**74.72 ± 0.55^{d}**	**25.28 ± 0.55^{d}**	**19.26 ± 0.45^{d}**	**45.97 ± 0.84^{e}**	**55.57 ± 0.76^{b,c}**
Sheep	**Mesenteric fat**	**85.79 ± 0.51^{e}**	**14.21 ± 0.51^{e}**	**13.20 ± 0.98^{b}**	**53.21 ± 0.61^{f}**	**82.71 ± 0.79^{d}**
	Perinephric fat	**82.49 ± 0.91^{f}**	**17.51 ± 0.91^{f}**	**13.40 ± 0.47^{a,b}**	**52.02 ± 0.64^{a,f}**	**77.03 ±0.97^{d}**

***Data represent the mean of three independent replicates ± SD, $^{a-f}$values with different superscripts within the same column for all treatments are significantly ($P<0.05$) different.**

Table (3): Deterioration criteria {pH, Total volatile basic nitrogen (TVBN, mg/100g), Thiobarbituric acid reactive substances (TBARS, mg/kg)} of beef fresh sausage formulated using fat of different food animals for 3 months of frozen storage.

		pH			
		0-time	**1 month**	**2 month**	**3 month**
Beef	**Mesenteric fat**	$_{i}5.61 \pm 0.012^{a*}$	$_{ii}6.19 \pm 0.006^{a}$	$_{iii}6.25 \pm 0.010^{a}$	$_{iv}6.34 \pm 0.012^{a}$
	Perinephric fat	$_{i}5.60 \pm 0.012^{a}$	$_{ii}6.23 \pm 0.010^{b}$	$_{iii}6.30 \pm 0.010^{b}$	$_{iv}6.37 \pm 0.010^{b,c,d}$
Buffalo	**Mesenteric fat**	$_{i}5.61 \pm 0.031^{a}$	$_{ii}6.22 \pm 0.010^{b}$	$_{ii}6.27 \pm 0.044^{a,b}$	$_{iii}6.37 \pm 0.012^{b,d}$
	Perinephric fat	$_{i}5.56 \pm 0.026^{b}$	$_{ii}6.19 \pm 0.010^{a}$	$_{iii}6.28 \pm 0.006^{b}$	$_{iv}6.38 \pm 0.006^{b}$
Camel	**Mesenteric fat**	$_{i}5.60 \pm 0.017^{a}$	$_{ii}6.23 \pm 0.015^{b}$	$_{iii}6.30 \pm 0.012^{b}$	$_{iv}6.36 \pm 0.015^{c,d}$
	Hump fat	$_{i}5.56 \pm 0.010^{b}$	$_{ii}6.26 \pm 0.006^{c}$	$_{iii}6.30 \pm 0.006^{b}$	$_{iv}6.36 \pm 0.006^{c,e}$
Sheep	**Mesenteric fat**	$_{i}5.54 \pm 0.020^{b}$	$_{ii}6.23 \pm 0.010^{b}$	$_{iii}6.30 \pm 0.010^{b}$	$_{iv}6.34 \pm 0.006^{a,e}$
	Perinephric fat	$_{i}5.53 \pm 0.020^{b}$	$_{ii}6.25 \pm 0.010^{c}$	$_{iii}6.29 \pm 0.017^{b}$	$_{iii}6.31 \pm 0.006^{f}$
	TVBN				
Beef	**Mesenteric fat**	$_{i}5.69 \pm 0.16^{a,b}$	$_{i}5.69 \pm 0.16^{a}$	$_{i}5.79 \pm 0.16^{a}$	$_{i}5.79 \pm 0.16^{a}$
	Perinephric fat	$_{i}6.07 \pm 0.43^{b,c}$	$_{i}6.07 \pm 0.16^{a,b}$	$_{i}6.44 \pm 0.28^{b,c}$	$_{ii}7.19 \pm 0.32^{b}$
Buffalo	**Mesenteric fat**	$_{i}5.97 \pm 0.16^{a,b,c}$	$_{i}5.97 \pm 0.16^{a,b}$	$_{i}6.07 \pm 0.16^{a,b}$	$_{ii}6.53 \pm 0.16^{c}$
	Perinephric fat	$_{i}6.25 \pm 0.16^{c}$	$_{i}6.25 \pm 0.58^{b}$	$_{i}6.44 \pm 0.28^{b,c}$	$_{i}6.53 \pm 0.16^{c}$
Camel	**Mesenteric fat**	$_{i}5.97 \pm 0.43^{a,b,c}$	$_{i}5.97 \pm 0.16^{a,b}$	$_{i}6.07 \pm 0.32^{a,b}$	$_{ii}7.09 \pm 0.16^{b}$
	Hump fat	$_{i}5.69 \pm 0.16^{a,b}$	$_{i,ii}6.06 \pm 0.32^{a,b}$	$_{i,ii}6.16 \pm 0.28^{a,b,c}$	$_{ii}6.53 \pm 0.43^{c}$
Sheep	**Mesenteric fat**	$_{i}5.60 \pm 0.28^{a}$	$_{i,ii}5.79 \pm 0.32^{a,b}$	$_{ii,iii}6.16 \pm 0.28^{a,b,c}$	$_{iii}6.63 \pm 0.16^{c}$
	Perinephric fat	$_{i}5.79 \pm 0.16^{a,b}$	$_{i}5.88 \pm 0.28^{a,b}$	$_{ii}6.63 \pm 0.43^{c}$	$_{iii}7.28 \pm 0.28^{b}$
	TBARS (Raw)				
Beef	**Mesenteric fat**	$_{i}0.291 \pm 0.025^{a}$	$_{i}0.302 \pm 0.060^{a,c}$	$_{i}0.333 \pm 0.039^{a,b}$	$_{i}0.351 \pm 0.047^{a}$
	Perinephric fat	$_{i}0.218 \pm 0.047^{b}$	$_{i}0.224 \pm 0.050^{b,d}$	$_{i}0.281 \pm 0.069^{a,c}$	$_{i}0.283 \pm 0.036^{b}$
Buffalo	**Mesenteric fat**	$_{i}0.291 \pm 0.063^{a}$	$_{i}0.304 \pm 0.061^{a,c}$	$_{i}0.315 \pm 0.005^{a,b,c}$	$_{i}0.348 \pm 0.005^{a}$
	Perinephric fat	$_{i}0.231 \pm 0.048^{a,}$	$_{ii}0.320 \pm 0.036^{c,e}$	$_{ii}0.322 \pm 0.043^{a,b,c}$	$_{ii}0.335 \pm 0.008^{a,c}$
Camel	**Mesenteric fat**	$_{i}0.242 \pm 0.034^{a,}$	$_{ii}0.315 \pm 0.012^{a,c}$	$_{ii}0.328 \pm 0.023^{a,b,c}$	$_{ii}0.348 \pm 0.016^{a}$
	Hump fat	$_{i}0.237 \pm 0.027^{a,}$	$_{i}0.250 \pm 0.021^{a,b}$	$_{i,ii}0.270 \pm 0.020^{c}$	$_{ii}0.302 \pm 0.005^{b,c}$
Sheep	**Mesenteric fat**	$_{i}0.265 \pm 0.014^{a,b}$	$_{ii}0.351 \pm 0.034^{c}$	$_{iii}0.395 \pm 0.009^{d}$	$_{iii}0.411 \pm 0.012^{d}$
	Perinephric fat	$_{i}0.263 \pm 0.012^{a,}$	$_{i}0.278 \pm 0.009^{a,b,d}$	$_{ii}0.356 \pm 0.025^{b,d}$	$_{ii}0.361 \pm 0.016^{a}$
	TBARS (Cooked)				
Beef	**Mesenteric fat**	$_{i}0.361 \pm 0.009^{a}$	$_{ii}0.442 \pm 0.012^{a,b}$	$_{ii}0.445 \pm 0.059^{a}$	$_{ii}0.486 \pm 0.060^{a,b}$
	Perinephric fat	$_{i}0.411 \pm 0.040^{b}$	$_{i}0.421 \pm 0.048^{a}$	$_{i}0.452 \pm 0.061^{a,b}$	$_{i}0.491 \pm 0.061^{a,b}$
Buffalo	**Mesenteric fat**	$_{i}0.403 \pm 0.012^{a,}$	$_{i}0.426 \pm 0.032^{a}$	$_{i}0.442 \pm 0.077^{a}$	$_{i}0.478 \pm 0.032^{a,b}$
	Perinephric fat	$_{i}0.429 \pm 0.027^{b}$	$_{ii}0.489 \pm 0.009^{b}$	$_{ii}0.538 \pm 0.027^{b}$	$_{ii}0.541 \pm 0.040^{a}$
Camel	**Mesenteric fat**	$_{i}0.429 \pm 0.034^{b}$	$_{i}0.455 \pm 0.024^{a,b}$	$_{i}0.434 \pm 0.020^{a}$	$_{i}0.445 \pm 0.023^{b}$
	Hump fat	$_{i}0.439 \pm 0.030^{b,}$	$_{i}0.458 \pm 0.032^{a,b}$	$_{i}0.460 \pm 0.031^{a,b}$	$_{i}0.502 \pm 0.079^{a,b}$
Sheep	**Mesenteric fat**	$_{i}0.432 \pm 0.016^{b,}$	$_{i}0.432 \pm 0.039^{a,c}$	$_{i,ii}0.452 \pm 0.055^{a,b}$	$_{ii}0.510 \pm 0.012^{a,b}$
	Perinephric fat	$_{i}0.473 \pm 0.012^{c}$	$_{i}0.478 \pm 0.009^{b,c}$	$_{i}0.489 \pm 0.055^{a,b}$	$_{i}0.523 \pm 0.047^{a,b}$

Data represent the mean of three independent replicates±SD, [a-c] Values for different superscripts within the same column, while [i-iv] Values for different superscripts within the same raw for all treatments are significantly ($P < 0.05$) different.

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