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EFFECT OF USING FATS OF DIFFERENT ANIMAL SPECIES ON FATTY ACID PROFILE, SENSORY QUALITY OF BEEF FRESH SAUSAGES

By

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ABSTRACT

Fat has an important role in the processing and sensory attributes 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 fatty acid profile and sensory quality of fresh sausages. Higher saturated fatty acids were recorded when fresh sausages processed using either buffalo or camel fats compared with those processed using beef or mutton fats. The highest level of Omega ω3 was obtained when camel mesenteric fat was incorporated. Sensory attributes revealed superiority of sausages formulated using beef or sheep fat, meanwhile lower scores were obtained when camel or buffalo fat was used. Based on this study, sheep fats may be recommended for production of high quality acceptable fresh sausages.

Keywords:
Fresh sausage, animal fat, fatty acid profile, sensory quality.

INTRODUCTION

The drastic changes of life style increased the consumption of sausages as fast food and sandwich component. Sausages represent a cheap delicious meat product and are gaining popularity all over the world because they represent quick easily prepared meals and solve the problems of shortage in fresh meat **(Hassan and Daoud, 1997).** Sausage manufacture is a simple process where meat undergo series of structural and chemical changes which are basic 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 making 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 represent 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 in their level of saturation and unsaturation which, are largely determined by fatty acids content that differ 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 have a major effect on adipose tissue and fatty acid composition for many parameters including saturated fatty acids (SFA), polyunsaturated fatty acids (PUFA), trans fatty acids and formation of different isomers **(Alfaia *et al.*, 2010)**. Studies on the comparison of characteristics of fresh sausages processed with fats from different animal species and different cuts within the animal are scarce. 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 fatty acid profile thiobarbituric acid reactive substances (TBARS) and sensory attributes of oriental fresh sausage.

Materials and methods:

Experimental design:

Eight Treatments based experiment with three independent replicates was performed to compare the fatty acid profiles and sensory attributes of 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 food 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, flaked 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 prepared from 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:

Analysis of fatty acids profile:

The total lipids from each of the examined samples were extracted (in duplicate) with hexane at 1:50 (wt/vol) ratio in each extraction operation **(Romero, *et al.,* 1998)**. The extraction efficiency of fatty acids was 99%. The fatty acids content of each sample were extracted according to **Folch *et al.* (1957)**. Fatty acid methyl esters were prepared from total lipid by using rapid method according to the method of **IUPAC (2000)**. Fatty acid methyl esters of extracted sausage fat were quantified by gas-liquid chromatography (HP 6890 GC capillary) equipped with a flame ionization detector (FID) using a 60 m x 0.32 mm x 0.25 um DB-23 capillary column. The injector and detector temperatures were set at 230 °C and 250 °C, respectively. Hydrogen gas (at flow rate 40 ml/min.) was used as carrier gas and temperature programming was from 150 to 170°C at 10 °C/min and then from 170°C to 192 °C at 5°C/min, holding five min then 192 °C to 220 °C during 10 min . Individual methyl esters were identified by comparison to known standards. Fatty acid peak areas (determined by gas chromatography) were used to calculate amounts of fatty acids and expressed on a percentage basis according to calculations described by **Slover and Lanza (1979)**.

Sensory evaluation:

Different oriental sausage trials were subjected to sensory evaluation after storage at -18°C on the 2nd day of storage at-18°C. The guidelines of **AMSA (1995)** were followed during sensory evaluation. Sensory evaluation was performed on cooked samples according to the schemes of **Magoro *et al.* (2012) and Kerr *et al.*(2005)**.From each trial individual cylindrical fresh sausages fingers were placed in aluminum plates and wrapped with aluminum foil to limit moisture loss. Cooking was performed in a forced draught oven (Heraeus,D-63450 Hanau, Germany) at 180°C till core temperature reached 75 ºC measured in the geometric center of thecylindrical fresh sausage.Thecooking temperature was monitored bya needle thermocouple probe attached to a previously calibrated handheld thermometer (Hanna HI 985091-1; Pasadena, TX,

USA).From the middle part of each fresh sausage cylindrical fingers, pieces of approximately 2 cm length were cut and served at room temperature. The cooked sausage was maintained warm in the oven until testing within 3-8 min. Nine experienced panelists (from both sexes in the age range of 25 to 45 years) were chosen from the staff members of the Department of Food Hygiene and Control at Faculty of Veterinary Medicine, Cairo University, Egypt. Panelists were selected on the basis of previous experience in consuming oriental fresh sausage.Moreover, they received a preparatory session prior to testing so that each panelist could thoroughly discuss and clarify each attribute to be evaluated. Samples were coded with random numbers and panelists were asked to evaluate them in a randomized order and asked to assign a numerical value between 1 and 9 where 9 denotes extremely acceptable and 1 denotes extremely unacceptable for following attributes : appearance 1(extremely poor)-9 (excellent) ; Aroma 1 (extremely unacceptable)-9 (excellent); Flavor 1 (imperceptible) -9 (extremely intense); Tenderness 1 (disliked extremely)-9 (liked extremely), Juiciness 1 (extremely dry)-9(extremely moist),Taste 1 (extremely poor)- 9(excellent) and finally for fatty feeling (fat left on mouth after swallowing is desirable or not)1(extremely undesirable)-9 (extremely desirable).At the end of evaluation of the given sample, each panelist was asked to give a score for overall acceptability from 1 (dislike extremely) to 9 (liked extremely). Also panelists asked to record any notes they found in the given samples not mentioned in the previous scheme. Tap water was provided between samples to cleanse the palate. All testing was carried out under controlled conditions (in special roomwith controlled temperature,free fromnoise and odorwith adequate lightening).

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 error (SE) were determined by least square difference test (LSD) procedure. Main effects were considered significance at $P<0.05$.

RESULTS AND DISCUSSION

Fatty acid profile of raw sausages formulated using different food animal fats.

Saturated fatty acids (SFA) of fresh sausage formulated using mesenteric or perinephric fat obtained from buffalo or camel revealed significant ($P<0.05$) higher values when compared with those formulated using fat obtained from beef or sheep (Table 1). Fresh sausages

formulated with perinephric fat of beef, buffalo and sheep exhibited significantly (P<0.05) higher SFA values in comparison with those formulated with mesenteric fat of the same species. However, fresh sausage formulated using camel mesenteric fat showed significantly (P<0.05) higher SFA values than that formulated with camel hump fat. The SFA values of fresh sausage formulated with camel fat were in good agreement with the results of **Emmanuel and Nahapetian (1980) and Kadim *et al*. (2002)** who observed higher saturation in mesenteric fat than hump fat. Moreover, higher saturation of buffalo fat was observed by **Steenkamp (2000).** It was observed that high SFA concentrations in fresh sausage formulated using fat of different animal species was associated with high concentrations of Palmitic (16:0) and Stearic (18:0) fatty acids or both of them. Nearly the same concentration of stearic fatty acid for perinephric beef fat was recorded by **Leat (1975)**. It has been reported by **Borghese *et al.* (1978)** that, the high SFA level in buffalo fat (perinephric or mesenteric) was attributed to higher concentrations of Stearic (18:0) fatty acid which was higher in buffalo fat when compared with that of beef. Moreover, high level of Meristic fatty acid (14:0) has been recorded when camel hump fat was incorporated in fresh sausage (Table1,2).Total unsaturated fatty acids (TUFA) concentration of fresh sausages formulated using mesenteric fat of Beef or sheep were significantly (P<0.05) higher than those of sausages formulated using other types of fat. Meanwhile, fresh sausage formulated using mesenteric or perinephric fat of buffalo or camel revealed significantly (P<0.05) lower concentrations of TUFA compared to sausages formulated using fats of Beef or sheep. Elevated TUFA is mainly interrelated with increase in Oleic Fatty Acid(C18:1)concentration (Tables1,2). Monounsaturated fatty acid concentrations in fresh sausage formulated using different fat types revealed the same patterns of TUFA. Polyunsaturated fatty acid concentrations of fresh sausages formulated with beef mesenteric or perinephric fat as well as buffalo perinephric fat were significantly (P<0.05) lower than those of sausages formulated with camel mesmeric or hump fat, sheep mesenteric or perinephric fat and buffalo mesmeric fat.Moreover, it was observed that fresh sausages formulated using camel mesenteric fat, sheep perinephric fat or buffalo mesenteric fat exhibited the highest concentrations of PUFA (Tables 1, 2).These observations were in agreement with **Wood *et al.* (2008)** who reported a high PUFA concentration adipose tissue of sheep. Concerning Trans fatty acids fresh sausages formulated with beef mesenteric or perinephric fat demonstrated the highest significant *(P*<0.05) values while the lowest significant (P<0.05) value was obtained

from fresh sausages formulated with sheep perinephric fat (Tables 1,2). The highest concentrations of Omega ω3 fatty acids were observed in fresh sausages formulated with camel mesenteric fat (1.02%) followed by fresh sausages formulated using camel hump fat (0.44%). However, the lowest concentration for Omega ω3 fatty acids were recorded in fresh sausages formulated with buffalo mesenteric fat (0.26%). On the other hand, the highest concentration of Omega ω6 fatty acids was observed in fresh sausage formulated with buffalo mesenteric fat (2.98%) followed by that formulated with sheep perinephric fat (2.835%), meanwhile, the lowest concentrations were obtained from sausage formulated using mesenteric fat of camel (2.255%) (Table 1and 2).

Effect of cooking on the fatty acid profile of fresh sausages formulated using different food animal fats.

After cooking, the level of saturated fatty acids increased significantly ($P<0.05$) in cooked sausages when compared with those of raw sausages in all formulas of fresh sausages except in fresh sausages formulated using beef perinephric fat or sheep mesenteric or perinephric fat which revealed significant ($P<0.05$) reduction in saturated fatty acids after cooking. The level of MUFA and TUFA revealed non-significant ($P<0.05$) reduction after cooking in all sausage formulations except in formulations where camel mesenteric or hump fat and sheep mesenteric fat were incorporated in the formulation. The levels of PUFA revealed non-significant ($P>0.05$) changes after cooking of sausages formulated using different types of fats except sausages formulated using buffalo perinephric fat or sheep perinephric fat where significant ($P<0.05$) increase has been observed. However, non-significant ($P>0.05$) increase in the concentrations of Omega ω6 FA after cooking in all formulations has been observed. The concentrations of Trans fats showed significant ($P<0.05$) elevation in formulas in which beef mesenteric or perinephric fats and sheep mesenteric or perinephric fats were incorporated. Non-significant ($P>0.05$) change in concentrations of Trans fats observed in formulation where buffalo mesenteric fat has been included. However, significant ($P<0.05$) reduction in the levels of Trans fats was evident when buffalo perinephric fat or camel mesenteric or perinephric fats were involved during formulation of fresh sausages (Table 1and 2).

Sensory quality of fresh sausages formulated using different food animal fats.

Incorporation of fat at different levels (10-20 %) into meat products has been associated with improvement of the tenderness and juiciness of these products **(Kregel, *et al.*, 1986; Wood**

***et al.,* 2008)**. The sensory scores of fresh sausages formulated using different animal fat from different location are presented in (Table 3). The appearance scores of fresh sausages formulated using different animal fat revealed non-significant (P>0.05) change among different formulations. Formulations of fresh sausages processed using buffalo perinephric fat or camel mesenteric or perinephric fats revealed significant (P<0.05) reductions in the scores of aroma, flavor, Taste and fatty feeling when compared with fresh sausages formulated using beef mesenteric or perinephric fats, buffalo mesenteric fat or sheep mesenteric or perinephric fats. The tenderness and juiciness scores revealed significant (P<0.05) reduction in fresh sausage formulae processed using buffalo perinephric or camel hump fats. Undesirable mouth fatty feelings were more noticeable by panelists in fresh sausages formulae processed using camel mesenteric or hump fats associated with significant (P<0.05) lowering of the scores of these formulae in comparison with other formulae. The overall acceptability scores were significant (P<0.05) lower in fresh sausages manufactured using buffalo perinephric fat or camel mesenteric and hump fats this results are in agreement with **Padda *et al*. (1986)** who reported that inclusion of 15 to 20 % of buffalo fat in comminuted meat products resulted in undesirable mouth coating, after taste problems. The lowering of sensory scores in fresh sausages processed using these fats may be attributed to the higher concentration of saturated fatty acids especially Palmitic (16:0) and Stearic (18:0) fatty acids, which have been observed in these sausages formulations (Table 1and 2).

CONCLUSION

It can be concluded from this study that, fresh sausages formulated with fats from buffalo or camel revealed higher saturation level when compared with those formulated with other fats. Moreover, the highest PUFA level was recorded for sausages formulated using mesenteric fat of camel. The highest level of Trans fatty acids were obtained when beef fat (mesenteric or perinephric) was used while the lowest level was recorded when sheep perinephric fat was used. Sausages formulated with beef or sheep fat revealed higher sensory scores, meanwhile lower scores were obtained when camel or buffalo fat was used. Fresh sausages formulated with sheep fats revealed high level of PUFA, Omega ω3 and Omega ω6 as well as low Tran's fatty acid level and high sensory attributes, therefore, sheep fat can be recommended as a good sources of fats for production of high quality and acceptable fresh sausages.

Table (1): Concentration of different fatty acids of beef fresh sausage processed using fat of different food animals before and after cooking (%)

	Beef				Buffalo				Camel				Sheep			
	Mesenteric (omental) fat		Perinephric fat		Mesenteric (omental) fat		Perinephric fat		Mesenteric (omental) fat		Hump fat		Mesenteric (omental) fat		Perinephric fat	
	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked
C8:0	0.010*	0.010	0.015	0.010	0.010	0.010	0.010	0.010	0.015	0.015	0.030	0.035	0.035	0.020	0.015	0.010
C10:0	0.055	0.050	0.080	0.070	0.015	0.020	0.020	0.020	0.035	0.040	0.060	0.070	0.160	0.135	0.165	0.140
C12:0	0.065	0.060	0.100	0.090	0.040	0.035	0.060	0.060	0.195	0.220	0.250	0.305	0.100	0.090	0.110	0.100
C13:0	0.015	0.010	0.020	0.020	0.015	0.020	0.020	0.020	0.040	0.040	0.050	0.050	0.045	0.040	0.030	0.030
C14:0	2.865	2.910	3.555	3.405	2.055	2.160	2.600	2.670	2.98	3.250	4.655	5.250	2.895	2.705	3.600	3.435
C14:1	0.355	0.360	0.390	0.370	0.075	0.075	0.110	0.105	0.065	0.075	0.070	0.065	0.265	0.245	0.265	0.255
C15:0	0.460	0.465	0.610	0.600	0.485	0.480	0.570	0.550	1.130	1.195	0.925	1.245	1.100	1.050	0.890	0.865
C15:1	0.315	0.320	0.370	0.365	0.425	0.435	0.380	0.385	0.420	0.305	0.310	0.340	0.255	0.245	0.155	0.150
C16:0	21.455	21.62	23.48	23.10	23.05	23.595	25.605	25.98	24.79	25.735	27.415	28.695	21.255	20.78	23.70	23.295
C16:1	1.695	1.825	1.855	1.970	0.970	1.015	1.105	1.325	1.575	1.615	1.695	1.750	1.660	1.355	1.915	1.595
C17:0	1.385	1.365	1.44	1.445	1.41	1.41	1.44	1.405	1.825	1.765	1.37	1.345	3.21	3.25	3.36	3.38
C17:1	0.515	0.520	0.545	0.520	0.325	0.330	0.350	0.325	0.550	0.510	0.485	0.460	1.090	1.115	1.200	1.230
C18:0	27.515	27.325	26.18	26.37	38.345	38.105	35.685	35.775	31.51	31.01	26.69	25.82	25.33	25.68	23.855	24.045
C18:1	36.64	36.45	34.62	34.82	25.71	25.48	25.28	24.95	26.45	26.415	27.225	26.58	35.64	35.38	34.71	34.95
C18:2 trans	0.850	0.945	0.860	0.900	0.725	0.725	0.735	0.715	0.740	0.695	0.820	0.805	0.715	0.770	0.675	0.710
C18:2	2.290	2.265	2.235	2.255	2.760	2.800	2.475	2.435	1.855	1.865	2.400	2.325	2.615	2.720	2.710	2.860
C18:3n6	0.175	0.170	0.185	0.185	0.220	0.215	0.235	0.220	0.400	0.355	0.320	0.295	0.145	0.150	0.125	0.155
C18:3n3	0.330	0.325	0.335	0.335	0.260	0.295	0.285	0.320	1.020	1.000	0.440	0.390	0.400	0.380	0.410	0.440
C20:0	0.250	0.260	0.270	0.265	0.310	0.285	0.280	0.275	0.645	0.540	0.490	0.430	0.135	0.190	0.125	0.135
C20:1	0.295	0.315	0.230	0.230	0.200	0.180	0.160	0.155	0.360	0.230	0.685	0.510	ND*	0.160	0.095	0.105
C22:0	0.015	0.035	0.035	0.015	0.06	ND	0.030	ND	0.035	ND	0.045	ND	ND	ND	ND	ND
Total Unknown	2.4	2.37	2.545	2.625	2.49	2.3	2.54	2.285	3.34	3.095	3.53	3.195	2.915	3.06	1.85	2.07

***Data represent the mean of three independent replicates, ND: not detectable.**

Table (2): Concentrations fatty acid Types of beef fresh sausage processed using fat of different food animals before and after cooking (%)

	Beef				Buffalo				Camel				Sheep			
	Mesenteric (omental) fat		Perinephric fat		Mesenteric (omental) fat		Perinephric fat		Mesenteric (omental) fat		Hump fat		Mesenteric (omental) fat		Perinephric fat	
	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked	Raw	Cooked
SFA	54.09 ± 0.00^{a,j,*}	54.11 ± 0.01^{a,j}	55.79 ± 0.02^{b}	55.39 ±0.13^{c}	65.80 ±0.95^{d}	66.12 ± 0.12^{e}	66.32 ± 0.017^{e}	66.77 ± 0.07^{f}	63.20 ± 0.00^{g}	63.81 ± 0.02^{h}	61.98 ± 0.08^{i}	63.25 ± 0.15^{g}	54.27 ± 0.15^{a}	53.94 ± 0.05^{j}	55.85 ± 0.06^{b}	55.44 ± 0.00^{c}
MUFA	39.82 ± 0.03^{a}	39.79 ± 0.02^{a}	38.01 ± 0.01^{b}	38.28 ± 0.08^{b,i}	27.71 ± 0.06^{c}	27.52 ± 0.10^{c,d}	27.39 ± 0.02^{d}	27.25 ± 0.12^{d}	29.42 ± 0.03^{e,f}	29.15 ± 0.03^{e}	30.47 ± 0.09^{g}	29.71 ± 0.10^{f}	38.91 ± 0.15^{h}	38.44 ± 0.28^{i}	38.34 ± 0.01^{i}	38.29 ± 0.02^{b,i}
PUFA	2.80 ± 0.01^{a}	2.76 ± 0.00^{a}	2.76 ± 0.00^{a}	2.78 ± 0.03^{a}	3.24 ± 0.02^{b,f}	3.31 ± 0.04^{b}	2.10 ± 0.00^{c}	2.98 ± 0.02^{c}	3.28 ± 0.02^{b,f}	3.22 ± 0.03^{d,f}	3.16 ± 0.00^{d}	3.01 ± 0.02^{c}	3.16 ± 0.00^{d}	3.25 ± 0.01^{b,f}	3.25 ± 0.03^{b,f}	3.46 ± 0.05^{e}
TUFA	42.61 ± 0.04^{a}	42.55 ± 0.02^{a}	40.77 ± 0.02^{b}	41.05 ± 0.12^{b}	30.95 ± 0.08^{c}	30.83 ± 0.15^{c}	30.38 ± 0.02^{d}	30.22 ± 0.09^{d}	32.70 ± 0.00^{e}	32.37 ± 0.00^{f}	33.63 ± 0.09^{g}	32.72 ± 0.12^{e}	42.07 ± 0.15^{h}	41.69 ± 0.27^{i}	41.59 ± 0.04^{i}	41.74 ± 0.08^{i}
Trans-FA	0.850 ± 0.00^{a}	0.945 ± 0.014^{b}	0.860 ± 0.00^{a}	0.900 ± 0.01^{c}	0.725 ± 0.01^{d,f}	0.725 ± 0.00^{d,f}	0.735 ± 0.00^{d,f}	0.715 ± 0.00^{d,e,f}	0.74 ± 0.01^{d}	0.695 ± 0.00^{e,i}	0.820 ± 0.00^{g}	0.805 ± 0.00^{g}	0.715 ± 0.01^{d,e}	0.770 ± 0.01^{h}	0.675 ± 0.01^{i}	0.710 ± 0.01^{e,f}
PUFA/SFA	0.0517 ± 0.00027^{a}	0.0510 ± 0.00017^{a,b}	0.0494 ± 0.00017^{c}	0.0501 ± 0.0007 0^{b,c,d}	0.0492 ± 0.00042^{c}	0.0501 ± 0.0007^{b} .c.d	0.0452 ± 0.00003^{e}	0.0446 ± 0.000 34^{e}	0.0518 ± 0.00042^{a}	0.0505 ± 0.0005 2^{a,c}	0.0510 ± 0.00003 a,d	0.0476 ± 0.00048^{f}	0.0582 ± 0.00027^{g}	0.0603 ± 0.00028^{h}	0.0581 ± 0.00064^{g}	0.0623 ± 0.0009 9^{i}
Omega ω3	0.330 ± 0.000^{a}	0.325 ± 0.002^{a,b}	0.335 ± 0.002^{a}	0.335 ± 0.002^{a}	0.260 ± 0.005^{c}	0.295 ± 0.025^{a,c}	0.285 ± 0.002^{b,c,d}	0.320 ± 0.028^{a,d}	1.020 ± 0.028^{e}	1.000 ± 0.023^{e}	0.440 ± 0.000^{f}	0.390 ± 0.000^{g}	0.400 ± 0.011^{f,g}	0.380 ± 0.000^{g}	0.410 ± 0.000^{f,g}	0.440 ± 0.011^{f}
Omega ω6	2.465 ± 0.014^{a}	2.435 ± 0.008^{a}	2.420 ± 0.005^{a}	2.440 ± 0.028^{a}	2.980 ± 0.017^{b}	3.015 ± 0.020^{b}	2.710 ± 0.000^{c,d}	2.655 ± 0.002^{d,f}	2.255 ± 0.002^{e}	2.220 ± 0.011^{e}	2.720 ± 0.005^{c}	2.620 ± 0.023^{f}	2.760 ± 0.017^{c}	2.870 ± 0.011^{g}	2.835 ± 0.031^{g}	3.015 ± 0.043^{b}

***Data represent the mean of three independent replicates ± SE**

SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids, TUFA, total unsaturated fatty acids, Trans-FA, Trans fatty acids

$^{a-i}$Values with different superscripts within the same raw for each parameter are significantly (P <0.05) different.

Table (3): Mean ±SD sensory panel scores of cooked experimentally produced fresh sausage using different fat types on 0-time.

	Beef		Buffalo		Camel		Sheep	
	Mesenteric (omental) fat	Perinephric fat	Mesenteric (omental) fat	Perinephric fat	Mesenteric (omental) fat	Hump fat	Mesenteric (omental) fat	Perinephric fat
Color	8.00 ± 0.00^{a}*	8.00 ± 0.00^{a}	7.67 ± 0.33^{a}	7.33 ± 0.33^{a}	7.33 ± 0.33^{a}	7.67 ± 0.33^{a}	8.00 ± 0.57^{a}	7.67 ± 0.33^{a}
Aroma	8.33 ± 0.33^{a}	8.00 ± 0.00^{a}	8.00 ± 0.00^{a}	6.67 ± 0.33^{b}	5.33 ± 0.33^{c}	$6.00 \pm 0.00^{b,c}$	8.33 ± 0.33^{a}	8.33 ± 0.33^{a}
Flavor	7.67 ± 0.33^{a}	7.67 ± 0.33^{a}	7.67 ± 0.33^{a}	6.00 ± 0.00^{b}	5.33 ± 0.33^{b}	5.67 ± 0.33^{b}	8.00 ± 0.57^{a}	8.00 ± 0.00^{a}
Taste	7.67 ± 0.33^{a}	7.33 ± 0.33^{a}	7.33 ± 0.33^{a}	6.00 ± 0.00^{b}	5.33 ± 0.33^{b}	5.67 ± 0.33^{b}	8.00 ± 0.00^{a}	7.67 ± 0.33^{a}
Tenderness	8.00 ± 0.00^{a}	7.67 ± 0.33^{a}	$7.33 \pm 0.33^{a,b}$	6.00 ± 0.00^{c}	$7.33 \pm 0.33^{a,b}$	$6.67 \pm 0.33^{b,c}$	7.67 ± 0.33^{a}	7.67 ± 0.33^{a}
Juiciness	8.00 ± 0.00^{a}	7.67 ± 0.33^{a}	$7.33 \pm 0.33^{a,b}$	6.00 ± 0.00^{c}	$7.33 \pm 0.33^{a,b}$	$6.67 \pm 0.33^{b,c}$	7.67 ± 0.33^{a}	7.67 ± 0.33^{a}
Fatty feeling	8.00 ± 0.00^{a}	$7.67 \pm 0.33^{a,b}$	$7.33 \pm 0.33^{a,b}$	5.67 ± 0.33^{c}	4.33 ± 0.33^{d}	4.67 ± 0.33^{d}	7.00 ± 0.00^{b}	$7.67 \pm 0.33^{a,b}$
Overall	7.95 ± 0.12^{a}	$7.71 \pm 0.14^{a,b}$	7.52 ± 0.04^{b}	6.24 ± 0.09^{c}	6.05 ± 0.12^{c}	6.14 ± 0.16^{c}	$7.81 \pm 0.20^{a,b}$	$7.81 \pm 0.17^{a,b}$

*Data represent the mean of three independent replicates ± SE

$^{a-d}$Values with different superscripts within the same raw for each parameter are significantly ($P < 0.05$) different.

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