Improving the properties of beef sausage

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Abstract: Palm olein was used as an alternative to sheep fat tail at different ratios in the processing of beef sausage. Fatty acids composition of the fatty materials were identified and determined using GLC and the oxidative stability of fatty blend in beef sausage treatments was measured. The results indicated that the sausage samples contained high palm olein gave improvements in water holding capacity, the plasticity values and cooking loss compared to the control sample (100 % sheep fat tail). The beef sausage samples were stored for three months under freezing (-18 ±2°C) and the results showed that the freezing storage occurred increments in both cooking loss and the total volatile nitrogen content. The findings appeared that beef sausage samples containing palm olein until the replacement ratio of 50% from sheep fat tail gave high quality compared to the control sample.
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1. Introduction:

Beef sausage is one of the most traditional meat products in Egypt and it is mostly produced from beef meat, fat tissues, dry rusk, salt and spices. Consumers are increasingly prefer products with low – fat content while retain good flavor and overall acceptability **(Lin and Huang, 2008).**Fat is vital to the rheological and structural properties of meat products and in the formation of a stable emulsion **(Keeton, 1994).** Meanwhile, Animal fat is considered as rich in saturated fatty acids with negative effect on human Health (**Ordonez *et al.*, 2001).**

The increasing demand for low – fat diets has led the food industry to develop or modify traditional food products to contain less animal fat **(Bloukas and Paneras, 1993; Mittal and Barbut, 1994 and Choi *et al.*, 2009).** Moreover, **Sundram (1997)** reported that palm olein has about 48% of oleic acid (C18:1). Also, he added that palm olein containing 44 – 48% oleic acid was equal in its plasma cholesterol and lipoprotein modulating effect to those of higher oleic acid containing oils including olive (70%), canola (65%) and rapeseed (65%).The level of oleic acid in palm olein is adequate to result in lipoprotein – cholesterol profile that protects against coronary heart disease (CHD) was examined in a series of human trials. Fortunately, **Hegsted (1991)** observed that used palm oil as a source of C16.0 in their test diet demonstrated that the cholestrolaemic effect due to C16.0 (palmitic acid) is significantly lower than that of lauric + myristic, (C12.0 + C14.0) combination. **Sundram *et al.* (1997)** cited that coconut oil is almost 85% saturated and it has been suggested that the higher cholesterol values after a coconut oil diet may be simply due to lower availability of linoleic acid (18.2).

Vural and Javidipour (2002) indicated that the replacement of beef fat with partially inter – esterified vegetable oils in frankfurters could improve the nutrient quality due to modification of the fatty acid composition. **Kayaardi and Gok (2003)** found more cholesterol in animal fat than vegetable oil meat products. Fat also plays a major role in the texture, juiciness and flavor of comminuted meat products. The sensory properties of fats make a diet flavorful, varied and rich **(Drewnowki, 1992).**

The aim of this investigation is to improve the beef sausage quality and to reduce the production cost.

2. Materials & Methods

Materials:

Imported frozen beef meat (Brazilian product) and fat tissues (sheep tail) were purchased from the private sector shop in the local market at Giza, Egypt. Palm olein was obtained from Arma Company for Food Industries, 10th of Ramadan city, Sharakia Governorate, Egypt. Other ingredients used in sausage preparation such as spices mixture, sodium chloride and bread crust were also purchased from local market at Giza, Egypt

All chemical materials used in this study were supplied from El- Gomohoria Company for Pharmaceutical, Cairo, Egypt.

Methods:

Preparation of the beef sausage samples and their formulas:

Beef sausages were processed as described by **Ibrahim (2004).** The control sample was prepared according to the following formula: frozen beef (67%), sheep fat tail (15.0%), ice water (10.0%), bread crust (5.0%), salt (2.0%) and spices (1. 0%). Other sausage treatments were prepared by replacing sheep fat tail with palm olein at the levels of 33.33, 50.0, 66.66 and 100% as shown in Table (1). Frozen beef meat was cut into approximately 5 cm cubes. Beef meat and sheep fat tail were minced twice with the ice water using mixer. The other ingredients were added and mixed together. The mixture was ground for a third time using a laboratory mixer (Hobbart Kneading machine) for 10 minutes. The obtained emulsion was stuffed into a nature casings which were hand linked at about 15 cm intervals. All treatments were aerobically packaged in a foam plate, wrapped with polyethylene film and stored at -18°C for 3 months. Samples were taken for analysis every month periodically.

Preparation and identification of the fatty acid methyl esters:

The fatty acids methyl ester of palm olein and sheep fat were prepared using esterification with cold methanolic solution containing potassium hydroxide as catalyst. The fatty acid methyl esters of the above fatty materials were separated and quantitatively determined using Gas–liquid chromatography (Agilent 6890 series GC) according to the method described in **IOOC (2001).**

The oxidative stability of the fatty materials:

The fatty materials in beef sausage samples after their extracting by n-hexane (micelles) were separately evaporated using Rotary evaporator to get the fatty materials then the obtained fatty materials were determined the oxidative stability using 679 Reanimate (Metrohn Herisoel Co., Switzerland) at 100^oC with an air flow rate at 20 L / h according to the method described by **Mendez *et al.* (1997).**

Some chemical analyses of beef sausage samples:

Chemical composition (moisture, protein, fat and ash) of beef sausage treatments was determined according to **A.O.A.C. (2000).**Total carbohydrate was calculated by the difference as follows:

Total carbohydrate = 100 – (moisture + protein + fat + ash).

Thiobarbituric acid (TBA) value was determined according to the method described by **Egan *et al.* (1981)** and the total volatile nitrogen (TVN) was determined according to the method published by **Winton and Winton (1958).**

Some physical analyses of beef sausage samples:

Water Holding Capacity (WHC) and plasticity of sausage treatments were measured according to the filter press method of **Soloviev (1966).** The cooking loss of prepared sausages was determined and calculated as the method described by **AMSA (1995)**. This measurement was carried out after cooking in hot water at 85^0C for 15 min.

Organoleptic evaluation of beef sausage samples:

Organoleptic evaluation of beef sausage treatments was carried out according to **Morr (1970)** by aid of ten members of the Meats and Fish's Res. Dept., Food Technology Research Institute. Judging scale for each factor was as follows: (10) excellent, (9) Very good, (8) Good, (7) Medium, (6) Fair, (5) Poor, (4) Very poor and (3) extremely poor.

Statistical analysis:

Data were subjected to Analysis of Variance (ANOVA). Means comparison was performed using Duncan̕s test at the 5% level of probability as reported by **Snedecor and Cochran (1994).**

3. Results and Discussion

The chemical composition of beef sausage samples:

The chemical composition of beef sausage treatments made from substitution of sheep fat tail by different ratios of palm olein is shown in Table (2). From these results, it could be noticed that moisture content for fresh and frozen sausage samples decreased by increasing palm olein substitute ratio from zero to 100% from the fatty materials (15gr.). Moisture content decreased from 62.30 to 60.52% for the control sample (100% sheep fat tail) at zero time and after three months from frozen storage, respectively. On the other hand, the moisture content of T4 (100% palm olein) also decreased from 61.45 at zero time to 60.22% after three months from frozen storage. From these results, it could be found that the decrement percentage in the moisture was lower inT4 (2.00%) than that found in the control sample (2.86%). These decrements are almost attributed to the content of palm olein (100% in T4 while it was zero% in the control sample). According to **Yilmaz *et al.*(2002)**, an increase in fat content as a result of added oil would reduce moisture content of the sausage samples.

Crude protein percentage of sausage samples had the same trend as moisture content of sausage samples. Crude protein in the fresh sausage (zero time), slightly decreased by increasing palm olein substitute ratio (Table, 2). Also, crude protein of all treatments slightly decreased by increasing frozen storage period to 3 months. These decrements may be due to protein hydrolysis by natural meat enzymes and bacterial enzymes as well as the loss of water soluble protein with separated drip. These results are similar with those obtained by **Gibriel *et al.* (2007).**

Fat percentage of sausage treatments had not the same trend for both moisture content and crude protein of sausage samples. Fat content of all sausage treatments increased by increasing palm olein substitute ratio. Fat content increased from 17.35% in the control sample (zero palm olein) to 17.48, 17.65, 17.87 and 18.15% by increasing palm olein substitute ratio to 33.33% (T1), 50.0% (T2), 66.66% (T3) and 100% (T4), respectively. Also, fat content of all treatments slightly increased by advancement of storage period. The highest increment recorded for T4 which increased from 18.15% at zero time to 19.04% after 3 months from frozen storage time. The percentage of ash for all sausage samples increased gradually with increasing time of storage. These results are harmony with that obtained by **Sharoba (2009).**Carbohydrates increased by increasing frozen storage time during the storage (3 months) for all sausage samples. It might be assumed that with drip separated during thawing, some losses of water and protein occurred as reported by **Fik *et al.* (1988)** and **Hsieh and Regenstein (1989).**

Some physical properties and cooking parameters of beef sausage samples:

Table (3) shows the water holding capacity (WHC), plasticity, cooking loss and cooking yield of beef sausage treatments as affected by substitution of fat tissues by palm olein at different ratios during frozen storage. Water holding capacity of all sausage at zero time ranged from 0.45 to 0.75 cm^2/0.3g. The lowest WHC (highest value 0.75 cm^2/0.3g) recorded for control sample (100% sheep fat tail). On the other hand, the highest WHC (0.45 cm^2/0.3g) recorded for sausage treatment (T4) which prepared with 100% palm olein. Generally, WHC values for all treatments slightly increased with increasing palm olein substitution. On the other hand, WHC values of all sausage treatments decreased by advancement of storage period. The loss of WHC during storage may be attributed to protein denaturation and loss of protein solubility **(Osheba *et al.*, 2013).**

Plasticity values took the same trend of WHC values. Plasticity values increased by increasing palm olein substitution ratio, meanwhile plasticity values decreased by increasing frozen storage period. This behavior may be due to protein denaturation and loss of protein solubility.

Cooking loss increased with increasing palm olein substitution ratio which increased from 22.36% in the control sample (zero palm olein) to 25.26% in T4 (100% palm olein) at zero time. This may be attributed to the excessive fat separation (**Mansour and Khalil, 1999**).Also, the findings show that cooking loss of all samples increased during frozen storage for 3 months except T1and T2 at zero time. These results may be due to water holding capacity which recorded decrements. Higher values of cooking yield recorded in T1, followed by T2 and control sample, (78.88, 78.31 and 77.64%, respectively). While, the lowest cooking yield (74.74%) recorded in T4 which contained 100% palm olein (15gr.) at zero time. From the above results, it can be noticed that the cooking yield decreased with increasing frozen storage time. Cooking losses of sausages decreased with decreasing in fat level, (**EmelCengiz and NalanGokoglu, 2007**).

Changes in some chemical properties of beef sausage samples during frozen storage at -18 0C for 3 months:

From the results in Table (4), it could be noticed that total volatile nitrogen(TVN) of all sausage treatments ranged from 8.09 to 8.42 mg/100g at zero time. These values increased gradually with increasing frozen storage period. TVN values of all treatments were in the range of permissible level reported by Egyptian Standards Specifications(2005) which limited the content of TVN must be not over than 20 mg /100g. These results are similar with that obtained by **Ibrahim (2004).**

Also, from the same table, it could be observed that Thiobarbituric acid of all treatments at zero time ranged from 0.23 to 0.29 mg malonaldhyde/kg. As time of frozen storage progressed the Thiobarbituric acid values of all treatments increased gradually. The lowest Thiobarbituric acid recorded for sausage contained 100% palm olein (T4),meanwhile the highest increment of TBA value recorded for control sausage which reached 0.68 mg malonaldhyde /kg after 3 months from the frozen storage (-18^{o}C). Generally, the increments of TBA values which observed in all sausages treatments contained palm olein were less than that found in the control sausage (zero % palm olein). TBA value of all samples in the range of permissible level limited by **Egyptian Standards Specification (2005)** which limited that the value of TBA must be not over than 0.9mg malonaldhyde /kg for frozen sausage.

Organoleptic analyses:

Table (5) shows the sensory properties of beef sausage samples substituted the sheep fat tail with different levels of palm olein. Form statistical analysis of these data, it could be noticed that there were significant differences (P< 0.05) in all sensory properties between different sausage treatments. Scores of all sensory properties (color, aroma, texture, taste and overall acceptability) of sausage treatments significantly increased by increasing palm olein level from zero% (control sample) to 50% (T2). Meanwhile these scores significantly decreased by increasing substitution ratio from 50 T2 to 100% T4.Sausage treatment which prepared with 100% palm olein (T4) was significantly lower sensory properties than other sausage treatments except T3 being non-significant differences between them.

Also, from the same table, it could be noticed that overall acceptability significantly affected by addition of palm olein. The highest overall acceptability (8.80) was recorded for sausage prepared by substituted fat with palm olein at 50% (T2) followed by T1 (8.73) and control sample (8.60) with non-significant differences between them. The lowest overall acceptability recorded for T4 (7.60) followed by T3 (7.98) with significant differences between them.

On the other hand, the results indicated that using palm olein up to 50% from the total fatty blend gave somewhat the same results compared to the control sample wherefrom the sensory characteristics (color, aroma, texture and taste).

Table 1. Ingredients (%) used for the preparation of different sausage formulas.

Ingredients %	Control	T1	T2	T 3	T 4
Frozen beef meat	67	67	67	67	67
Sheep fat tail	15	10	7.5	5	-
Palm olein	-	5	7.5	10	15
Ice water	10	10	10	10	10
Bread crust	5	5	5	5	5
Sodium chloride	2	2	2	2	2
Spices mixture*	1	1	1	1	1

***Spices mixture** constituted of 2.79% cardamom; 3.64% nutmeg; 10.52% Arab yeast, 9.91% cinnamon, 8.00% clove, 14.61% rose wood, 4.97% thyme, 26.17% cubeb, 8.22% corengan and 11.17% white pepper.

Table (2). Chemical composition of beef sausage treatments during frozen storage at -18^{o}C for 3 months.

Components	Samples of sausages																			
	Control				T1				T2				T3				T4			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
	62.30	61.42	60.98	60.52	62.02	60.83	60.42	60.04	61.90	60.57	60.14	59.76	61.70	60.25	59.88	59.51	61.45	60.98	60.51	60.22
Moisture	13.44	12.75	12.37	12.03	13.40	12.85	12.52	12.22	13.36	12.98	12.64	12.38	13.30	13.09	12.81	12.53	13.26	13.20	13.02	12.70
Protein	17.35	17.61	17.85	18.38	17.48	17.77	18.01	18.57	17.65	17.91	18.18	18.73	17.87	18.07	18.30	18.88	18.15	18.17	18.49	19.04
Fat	2.86	2.89	2.92	2.97	2.81	2.84	2.86	2.92	2.82	2.83	2.85	2.87	2.83	2.84	2.86	2.89	2.87	2.90	2.92	2.94
Ash	4.05	5.33	5.88	6.10	4.29	5.71	6.19	6.25	4.27	5.71	6.19	6.26	4.30	5.75	6.15	6.19	4.27	4.75	5.06	5.10
Carbohydrate																				

Table (3).Some physical characteristics of beef sausage treatments during frozen storage at -18^{o}C for 3 months.

Samples / Analysis	Control				Formula 1				Formula 2				Formula 3				Formula4			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
WHC*	0.75	0.90	1.25	1.60	0.60	0.63	0.96	1.46	0.49	0.55	0.75	0.94	0.47	0.65	0.77	0.98	0.45	0.60	0.71	0.90
Plasticity **	5.34	4.48	3.72	3.08	5.40	4.65	3.99	3.41	5.46	4.84	4.26	3.77	5.50	5.02	4.56	4.14	5.52	5.18	4.82	4.48
Cooking loss (%)	22.36	25.08	26.93	29.85	21.12	23.04	25.41	28.39	21.69	24.34	26.01	28.90	23.04	26.28	28.45	31.27	25.26	28.93	31.71	34.90
Cooking yield (%)	77.64	74.92	73.07	70.15	78.88	76.96	74.59	71.61	78.31	75.66	73.99	71.10	76.96	73.72	71.55	68.73	74.74	71.07	68.29	65.10

***WHC = Water holding Capacity (cm^{2}/0.3g)**
Plasticity (cm^{2}**/0.3g)

Table (4). Changes in some chemical properties of beef sausage during frozen storage at -18C^{o} for 3 months.

Treatments	Storage period (months)							
	Zero time		1		2		3	
	TVN	TBA	TVN	TBA	TVN	TBA	TVN	TBA
Control	8.42	0.29	10.03	0.36	14.21	0.47	18.01	0.68
T1	8.30	0.27	9.92	0.33	13.08	0.43	17.82	0.56
T 2	8.21	0.26	9.78	0.30	12.88	0.38	17.68	0.44
T 3	8.18	0.24	9.63	0.28	12.30	0.35	17.51	0.40
T 4	8.09	0.23	9.50	0.26	11.73	0.30	17.08	0.33

TVN = total volatile nitrogen (mg/100g)
TBA = Thiobarbituric acid (mg malonaldhyde/kg)

Table (5). Effect of using palm olein on some sensory properties of beef sausage samples at zero time .

properties / Samples	Sensory Properties				
	Color	Aroma	Texture	Taste	Overall acceptability
Control	**8.1 ^{ab}**	**8.8 ^{a}**	**8.7 ^{a}**	**8.8 ^{a}**	**8.60^{a}**
T1	**8.2 ^{a}**	**9.0^{a}**	**8.8 ^{a}**	**8.9 ^{a}**	**8.73^{a}**
T2	**8.3 ^{a}**	**9.0^{a}**	**8.9 ^{a}**	**9.0 ^{a}**	**8.80^{a}**
T3	**7.7 ^{bc}**	**7.9^{b}**	**7.8 ^{b}**	**8.5 ^{ab}**	**7.98^{b}**
T4	**7.4^{c}**	**7.6^{b}**	**7.3^{c}**	**8.1^{b}**	**7.60^{c}**
LSD	**0.405***	**0.482***	**0.386***	**0.422***	**0.256***

Where: Mean values in the column row with the same letter are not significant different at 0.05 level. * Significant
LSD least significant differences

Fatty acids composition of palm olein and sheep fat tail;

The results found in Table (6) show the fatty acids composition of palm olein and sheep fat tail. The data referred that C18:2 /C16:0 ratios had higher percentage in sheep fat tail than that found in palm olein which were 0.256 and o.158 %, respectively. Furthermore, sheep fat tail had higher palmitic acid (C16:0) content (40.59%) compared with palm olein (22.35%) whereas the level of oleic acid (C18:1) for sheep fat tail and palm olein was nearly equal content (42.44 and 44.07%, respectively). Also, total un-saturated fatty acids recorded higher content in palm olein (56.11%) than in sheep fat tail (53.71) whilst, total saturated fatty acids recorded lower content (39.65%) in palm olein than that found in sheep fat tail (46.22%). These results for palm olein are somewhat equal with those reported by **Elham *et al.*(2009)**, whilst the data for sheep fat tail are agreement with that revealed by **Wood *et al.* (2008).**On the other hand, palm olein containing 44-48% oleic acid was equal in its plasma cholesterol and lipoprotein modulating effect to those of higher oleic acid containing oils including olive (70%), canola (65%) and rapeseed (65%) **(Sundram *et al.*, 1995).**

Table (6). Fatty acids composition (%) of the fatty materials used in this work.

Fatty acids	Sheep fat tail	Palm olein
C12:0	0.30	0.28
C14:0	1.01	4.19
Unknown-1	-	1.97
C16:0	40.59	22.35
C16:1	0.39	5.00
Unknown-2	-	1.19
C17:0	0.09	3.21
C17:1	0.04	2.63
C18:0	3.90	9.37
C18:1	42.44	44.07
C18:2	10.41	3.54
C18:3	0.25	0.61
Unknown-3	-	1.01
C20:0	0.33	0.25
C20:1	0.18	0.26
T. saturated fatty acids	46.22	39.65
T. unsaturated fatty acids	53.71	56.11
Ratio of saturated /unsaturated fatty acids (%)	86.05	70.66
C18:2 / C16: 0 (%)	0.256	0.158

Effect of using palm olein at different ratios on the shelf life (oxidative stability) of beef sausage samples:

The oxidative stability of oils and fats is one of the most important factors determining their shelf life **(Anwar *et al.*, 2003).** From the data found in Table (7), it can be seen that the oxidative stability of formula 4 recorded a higher increment at zero time and after three storage at – 18^{o}C (34.2 and 22.8 hr., respectively) compared with the control sample (18.6 and 13.7 hr., respectively). From the above results in the same table, it is obviously that the oxidative stability of formula 1 increased from 18.6 and 13.7 hr. at zero time and after 3 months to 34.2 and 22.8 hr. with increasing content of palm olein from 33.3% to100% of total fatty materials, respectively compared with the control sample (zero palm olein) which their oxidative stabilities recorded 18.6 and 13.7 hr. at zero time and after three months, respectively. These improvements in the oxidative stability are probably in as much as using of palm olein instead of sheep fat tail.

Form the above findings, it is clear that using of palm olein up to 50% from the fatty blend occurred improvements in the oxidative stability and sensory evaluation for T1 and T2 (33.3 and 50% palm olein) compared with that obtained in the control beef sausage (100% sheep fat tail).

Table (7). Effect of using palm olein on the oxidative stability (hr) of beef sausage after frozen storage for 3 months at – 18^{o}C.

Beef sausage samples	Oxidative stability at 100C^{0}(hr)	
	At zero time	After three months
Control	18.6	13.7
T 1	29.0	13.9
T 2	30.0	14.2
T 3	32.0	16.3
T 4	34.21	22.8

4. Conclusions

From all the above data in this work, it could be concluded that using palm olein in the preparation of beef sausage up to 50% from the fatty blend induced improvements in some parameters of these sausage since the oxidative stability increased beside the sensory characteristics recorded improvements.

Subsequently, it can be recommend that palm olein can be used to the contents of beef sausage up 50% from the fatty blend to rise the shelf life (the oxidative stability) and to decline the content of sheep fat tail (which it is higher price than palm olein) as well as to decrease the production cost of beef sausage.

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