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ARTICLE

Effect of Replacing Pork Fat with Vegetable Oils on Quality Properties of Emulsion-type Pork Sausages

Hyun-Jin Lee[1], Eun-Hee Jung[2], Sang-Hwa Lee[3], Jong-Hee Kim[4], Jae-Joon Lee[5], and Yang-Il Choi[1,*]

[1]*Department of Animal Science, Chungbuk National University, Cheongju 361-763, Korea*
[2]*Department of Food and Nutrition, Seowon University, Cheongju 361-742, Korea*
[3]*Seowon University Bio Organic Material & Food Center, Cheongju 361-742, Korea*
[4]*Hansalimfood Agricul. Corp., Goesan 367-922, Korea*
[5]*Department of Food and Nutrition, Chosun University, Gwangju 501-759, Korea*

Abstract

This study was conducted to evaluate the quality properties of emulsion-type pork sausages when pork fat is replaced with vegetable oil mixtures during processing. Pork sausages were processed under six treatment conditions: T1 (20% pork fat), T2 (10% pork fat + 2% grape seed oil + 4% olive oil + 4% canola oil), T3 (4% grape seed oil + 16% canola oil), T4 (4% grape seed oil + 4% olive oil + 12% canola oil), T5 (4% grape seed oil + 8% olive oil + 8% canola oil), and T6 (4% grape seed oil + 12% olive oil + 4% canola oil). Proximate analysis showed significant ($p<0.05$) differences in the moisture, protein, and fat content among the emulsion-type pork sausages. Furthermore, replacement with vegetable oil mixtures significantly decreased the ash content ($p<0.05$), increased water-holding capacity in emulsion-type pork sausages. Also, cholesterol content in T6 was significantly lower than T2 ($p<0.05$). In the texture profile analysis, hardness and chewiness of emulsion-type pork sausages were significantly ($p<0.05$) decreased by vegetable oil mixtures replacement. On the contrary, cohesiveness and springiness in the T4 group were similar to those of group T1. The unsaturated fatty acid content in emulsion-type pork sausages was increased by vegetable oil mixtures replacement. Replacement of pork fat with mixed vegetable oils had no negative effects on the quality properties of emulsion-type pork sausages, and due to its reduced saturated fatty acid composition, the product had the quality characteristics of the healthy meat products desired by consumers.

Key words: emulsion-type pork sausage, quality property, vegetable oil, fatty acid composition, pork fat

Introduction

Korean food consumption has increased sizably because of westernization and increasing national income. Owing to various and complicated social structures, Koreans have demanded more processed meat products as cooked and frozen foods (Koo *et al*., 2007). The output of domestic processed meat products increased considerably from 180,640 tons to 188,744 tons, but in 2012, it decreased by 153,946 tons (KMIA, 2013). The westernization of the Korean diet has increased the risks for obesity and disease. Therefore, modern eating habits increasingly reflect a preference for a health and wellness-oriented diet that includes low-fat, low-calorie, low-salt meals. In the past, the standard for food choice was simple nutrient intake to sustain life. Modern consumers have higher incomes and choose health-oriented foods and their demands for such foods have increased over time. Accordingly, meat-product manufacturers are developing new processing techniques and accepting a new nutrient system (Ballin, 2010; Biesalski, 2005; Weiss *et al*., 2010).

In general, the fat content of sausage is as high as 30%. Fat is a vital source of energy and essential fatty acids (Vural *et al*., 2004). It is also one of the three macronutrients the body requires and it has the key function of carrying fat-soluble vitamins (Mela, 1990). Fat in meat products also plays central roles in stabilizing meat emulsions, reducing cooking loss, improving water-holding capacity (WHC) and providing juiciness and hardness (Pietrasik and Duda, 2000; Yoo *et al*., 2007). However, foods with high animal fat content have high levels of saturated fatty acids and cholesterol. Diets high in animal fat may be associated with several types of obesity,

*Corresponding author: Yang-Il Choi, Department of Animal Science, Chungbuk National University, Cheongju 361-703, Korea. Tel: +82-43-261-2550, Fax: +82-43-272-2240, E-mail: yangilchoi@chungbuk.ac.kr

hypertension, cardiovascular disease and coronary heart disease (Özvural and Vural, 2008). Therefore, consumer demand for healthier products is growing and has stimulated the development of meat products with reduced fat content and altered fatty acid profiles (JimCnez-Colmenero, 1996).

Compared with animal fats, vegetable oils are free of cholesterol and have a higher ratio of unsaturated to saturated fatty acids (Liu *et al*., 1991). Vegetable oils such as olive oil and canola oil have been used as partial substitutes for pork backfat in low-fat frankfurters and other cooked products (Pappa *et al*., 2000; Park *et al*., 1989). Because vegetable oils differ considerably in their physical properties such as color, flavor, free fatty acids and fatty acid composition, different oils could have different effects on the quality characteristics and nutritional value of meat products. Vegetable oil has been used to extend the shelf life of several food products, including pork patties. However, effect of replacing animal fat with vegetable oil mixtures on the quality of sausages remains to be fully studied. Therefore, this study was conducted to evaluate effect of replacing pork fat with vegetable oil mixture on the quality properties of emulsion-type pork sausages.

Materials and Methods

Processing and sampling

Certified organic grade vacuum-packed, refrigerated lean pork and frozen pork backfat was obtained from Hansalim food Agricul. Corp. (Korea). Emulsion-type pork sausages were processed using six treatments (Table 1) : T1 (20% pork fat), T2 (10% pork fat + 2% grape seed oil + 4% olive oil + 4% canola oil), T3 (4% grape seed oil + 16% canola oil), T4 (4% grape seed oil + 4% olive oil + 12% canola oil), T5 (4% grape seed oil + 8% olive oil + 8% canola oil), and T6 (4% grape seed oil + 12% olive oil + 4% canola oil). The basic formulations for the sausages were as follows: lean pork (60%), water (20%), salt (1.3%), sodium tripolyphosphate (0.2%), natural seasoning (0.07%), fructo-oligosaccharide (0.7%), glutinous rice powder (1.7%) and seasoning (0.6%). The manufacturing process (Fig. 1) was as follows: Subcutaneous and excessive connective tissues were removed from pork and ground twice through a 9-mm plate. Six batches (10 kg) for experiment were prepared three replications. Minced meat was ground for 1 min using a bowl cutter (Talsa K30, DSL Food Machinery Ltd., Spain). Salt, tripolyphosphate, and half of ice were subsequently added and mixed for 2 min. After 1 min, fat and spices were added and emulsified for 1 min and the remaining ice was added to the batter. The final emulsified batter was obtained by applying additional 3 min mixing under high speed (bowl speed: 24 rpm, knife shaft speed: 2840 rpm). The temperature of the batter was maintained below 11.5°C. The batter was then stuffed into fibrous casings (Nalo Top, Kalle GmbH, Germany; 70-mm diameter) using a stuffer (IS-8, Sirman, Italy). The stuffed samples were cooked in a heating chamber (Thematec Food Industry Co., Korea) to the internal temperature of 75°C. The emulsified sausages were cooled and stored at 4°C. And the quality properties of emulsified sausages were evaluated at the meat science laboratory of Chungbuk National University (Cheongju, Korea).

Proximal analysis

Moisture, protein, lipid, and ash were assayed using the methods of the Association of Official Analytical Chemists (1995).

pH

A homogenizer (Nihonseiki, Tokyo, Japan) was used to homogenize 10 g of sample in 100 mL of distilled water for 30 s at 7000 rpm. The pH level of the homogenate was determined using a pH meter (Mettler Delta 340; Mettler-Toledo, Ltd, UK).

Table 1. Experimental design for emulsion-type pork sausages (Unit; %)

Items*	Pork fat	Grape seed oil	Olive oil	Canola oil
T1	20%	-	-	-
T2	10%	2%	4%	4%
T3	-	4%	-	16%
T4	-	4%	4%	12%
T5	-	4%	8%	8%
T6	-	4%	12%	4%

*T1, pork fat 20%; T2, pork fat 10% + grape seed oil 2% + olive oil 4% + canola oil 4%; T3, grape seed oil 4% + canola oil 16%; T4, grape seed oil 4% + olive oil 4% + canola oil 12%; T5, grape seed oil 4% + olive oil 8% + canola oil 8%; T6, grape seed oil 4% + olive oil 12% + canola oil 4%.

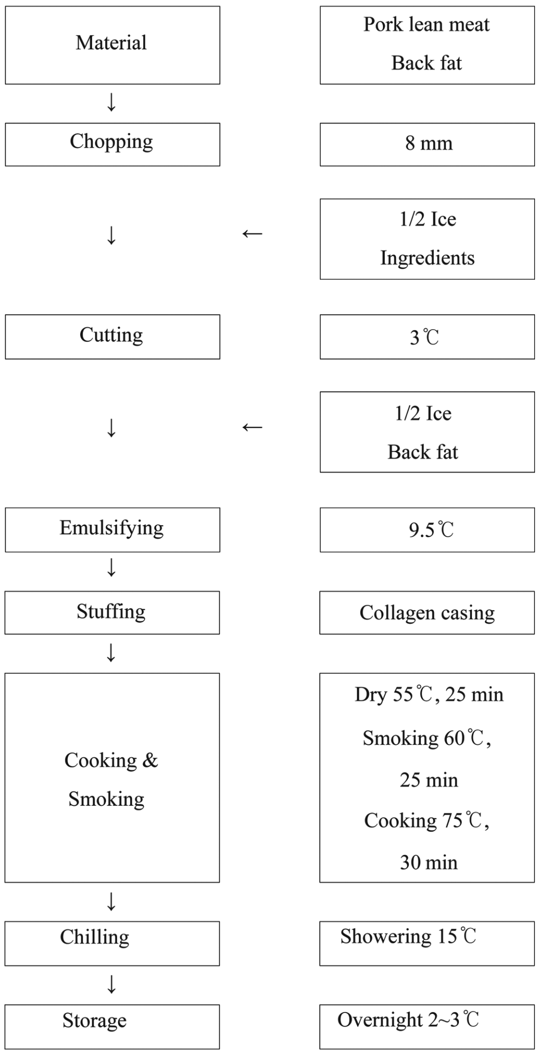

Fig. 1. Manufacturing process of emulsion-type pork sausage.

Water-holding capacity (WHC)

The centrifugation method described by Laakkonen *et al*. (1970) was used to measure WHC. Emulsion-type pork sausage samples (0.5 ± 0.05g) from each treatment group were placed in individual centrifugation tubes with filter units, heated for 20 min at 80°C, and cooled for 10 min. Samples were centrifuged at 2000 *g* for 10 min at 4°C, after which WHC was calculated as the change in weight for each sample.

Cooking loss

A 3-cm-thick slice (weight 100±5 g) of emulsion-type pork sausage from each treatment group was placed in a polypropylene bag, cooked for 40 min at 7°C in a water-bath, and cooled to room temperature. Cooking loss was calculated as the weight difference of samples before and after cooking.

Cholesterol

Freeze-dried samples (0.3 g) from each treatment group were homogenized with 12 mL of chloroform : methanol (2:1) Folch solution and let stand for 24 h at 4°C. Then, 10 mL deionized water was added and mixed well, and the samples were centrifuged at 3000 *g* for 20 min 4°C. The lower phases of the centrifuged samples were removed using a syringe and placed in a fume hood for 24 h. After complete evaporation, 1 mL glacial acetic acid was added to the samples and vortexed for 30 s. O-phthalaldehyde reagent (2 mL) and 1 mL H_2SO_4 were added to 0.1 mL vortexed sample and vortexed for 30 s. After 10 min, the absorbance was measured with a spectrophotometer (Optizen-3220UV, Mecasys, Korea) at 530 nm. A standard curve described through 10, 20, 30, 40, and 50 mL cholesterol standard stock solution and 40, 30, 20, 10, and 0 mL, respectively, of glacial acetic acid mixed solution was measured using the above procedure. And regression equation was obtained. Cholesterol content (mg/100 g, dry wet) was calculated using the following equation: Measured amount by standard curve × addition of glacial acetic acid × diluted rate × total lipid weight (mg) / sample weight.

Texture profile analysis (TPA)

A 3-cm-thick slice (weight 100±5 g) of emulsion-type pork sausage from each treatment group was placed in a polypropylene bag, cooked for 40 min at 70°C in a water-bath, and cooled for 30 min. Samples were cut into 1 × 1 × 1 cm (width × length × height) pieces for a double compression cycle test. Texture profile testing was performed using a Rheology Data System version 3.0 and a rheometer (Model Compac-100; Sun Scientific Co., Japan) with a table speed of 60mm/min and a load cell (max) of 4 kg.

Sensory evaluation

Well-trained in-house tasting panelists (n=5) evaluated sensory attributes of tenderness, juiciness, flavor and overall acceptability, using on a 5-point scale: 1-not salty, very tough, very dry, very mild, very unacceptable, 5- very salty, very tender, very juicy, very intense, very acceptability. The sample was evaluated in dependently by the panelists 3 different times.

Fatty acid composition

Total lipid was extracted with the Folch (1957) method. Samples were methylated in a water-bath at 100°C for 1 h according to the method of Lepage and Roy (1986). After cooling, the samples were added to hexane, and the top layer was removed. Separation and quantification of fatty acid methyl esters was carried out using a gas chromatograph (HP 5890II; Hewlett Packard Co., USA) equipped with a capillary column (100 m × 0.25 mm internal diameter × 0.20 μm film thickness). Nitrogen was used as the carrier gas, and the oven temperature was initially held at 180°C, then raised to a final temperature of 240°C (2°C/min). The injector and detector temperatures were maintained at 250°C.

Statistical analysis

Statistical analyses were carried out using the generalized linear model procedure of the SAS package (release 9.01, 2002). Means were compared using Duncan's multiple range test at a level of significance of $p<0.05$.

Results and Discussion

Proximate analysis of emulsion-type pork sausages in which pork fat has been replaced with vegetable oils

The result of the proximate analysis of emulsion-type pork sausages in which vegetable oils were substituted for pork fat are shown in Table 2. Significant differences among sausage samples were observed for all measured components ($p<0.05$). Moisture, protein, and ash were decreased by the addition of mixed vegetable oils, whereas fat content was increased. According to Lee and Kim (1986), pork backfat is composed of 16.09% water, 80.00% fat, and 4.20% protein. Therefore, the moisture and protein contents in emulsion-type pork sausages processed with pork fat were thought to be higher than those of sausages processed with mixed vegetable oils. However, this finding was not confirmed by the results of other studies of pork sausage in which pork fat was replaced with vegetable oils (Bloukas *et al*., 1996; JimCnez-Colmenero *et al*., 2010; Koo *et al*., 2009).

Effect of replacing pork fat with vegetable oils on the quality properties of emulsion-type pork sausages

Table 3 shows the pH, WHC, cooking loss, and total cholesterol values of emulsion-type pork sausages in which pork fat was replaced with mixed vegetable oils. The pH values of the treated sausages ranged from 6.14 to 6.29. Vegetable oil replacement significantly ($p<0.05$) increased WHC and decreased cooking loss in emulsion-type pork sausages. A previous study reported that the addition of cottonseed oil decreases the cooking loss values of sausage products, and the addition of pork fat can increase these values (Woo *et al*., 1995). The results of this study were similar to those of a study by Koo *et al.* (2009), in which the cooking loss values of patties processed with vegetable oils were significantly lower than those of patties processed with pork fat. Similar results have been observed in other studies (Asuming-Bediako *et*

Table 2. Effect of replacing pork fat with vegetable oils on proximate analysis of emulsion-type pork sausages*

Items	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
T1	$62.18±0.31^{a}$	$24.61±4.55^{a}$	$11.35±4.27^{c}$	$1.85±0.11^{a}$
T2	$60.79±0.26^{b}$	$21.37±1.45^{abc}$	$15.89±1.52^{b}$	$1.87±0.05^{a}$
T3	$58.95±0.63^{c}$	$21.79±1.03^{ab}$	$17.34±0.76^{ab}$	$1.61±0.17^{b}$
T4	$60.71±1.08^{b}$	$15.59±2.20^{d}$	$21.64±1.66^{a}$	$1.67±0.13^{ab}$
T5	$61.08±0.43^{b}$	$17.47±1.23^{cd}$	$19.62±1.27^{ab}$	$1.59±0.07^{b}$
T6	$60.52±0.88^{b}$	$16.87±2.68^{cd}$	$20.63±2.49^{a}$	$1.55±0.01^{b}$

*Treatments are the same as in Table 1.
$^{a-d}$Means±SD with different superscript letters indicate significant differences ($p<0.05$).

Table 3. Effect of replacing pork fat with vegetable oils on quality properties of emulsion-type pork sausages*

Items	pH	WHC (%)**	Cooking loss (%)	Cholesterol (mg/100 g)
T1	$6.29±0.01^{a}$	$73.15±2.70^{b}$	$1.22±0.34^{a}$	$46.46±7.54^{ab}$
T2	$6.26±0.01^{b}$	$74.49±3.13^{b}$	$0.57±0.07^{c}$	$53.51±9.96^{a}$
T3	$6.14±0.01^{c}$	$87.18±8.34^{a}$	$0.70±0.17^{bc}$	$45.15±9.42^{ab}$
T4	$6.31±0.01^{a}$	$80.27±3.12^{ab}$	$0.75±0.23^{bc}$	$45.17±7.41^{ab}$
T5	$6.16±0.03^{c}$	$89.82±5.16^{a}$	$1.11±0.11^{ab}$	$42.95±6.41^{ab}$
T6	$6.14±0.01^{c}$	$87.73±5.42^{a}$	$0.84±0.23^{abc}$	$38.25±1.33^{b}$

*Treatments are the same as in Table 1.
**Water holding capacity
$^{a-c}$Means±SD with different superscript letters indicate significant differences ($p<0.05$).

al., 2014; Whiting, 1987), suggesting that the difference in emulsifying capacity between pork fat and vegetable oils is small during processing. The cholesterol content in T6 was significantly lower than T2 ($p<0.05$). More addition of olive oil showed result that decrease of cholesterol content in the emulsion-type pork sausages. Also, these result was similar with report of Kayaardi and Gok (2003). According to the result of a study by Kang and Park (2007), the total cholesterol content in pork back fat is 81.45 mg/100 g, and the use of vegetable oils in meat products not only helps increase unsaturated fatty acids but also reduces cholesterol content (Gok *et al*., 2011; Kayaardi and Gok, 2003; Muguelza *et al*., 2003; Vural and Javidipour, 2002). Therefore, we concluded that the use of vegetable oils as a pork fat substitute decreases cholesterol content in emulsion-type pork sausages.

Effect of replacing pork fat with vegetable oils on the texture profile of emulsion-type pork sausages

The results of the comparative texture profile analysis of emulsion-type pork sausages in which pork fat was replaced with vegetable oil are shown in Table 4. Among all treatment groups, Hardness, cohesiveness, springiness, and chewiness values were highest in T1 ($p<0.05$). This result was obtained that fat content in T1 is significantly lower compared with other treatment groups. It was equal to report of Jung *et al.* (1998), which the less fat content, the higher hardness of meat products. Among the treatments with mixed vegetable oils, T4 had texture property values higher than those of T3, T5, and T6 ($p<0.05$). Jim-Cnez-Colmenero *et al*. (2010) reported that the texture property values of frankfurter sausages containing emulsified olive oil were significantly lower than those of sausages containing pork fat ($p<0.05$). These results were similar to those of other studies (Baer and Dilger, 2014; Choi *et al*., 2010; Park *et al*., 2005).

Effect of replacing pork fat with vegetable oils on the sensory properties of emulsion-type pork sausages

The results of the sensory evaluation of emulsion-type pork sausages in which pork fat was replaced with vegetable oil are shown in Table 5. Treatment without addition of the vegetable oil was higher score in saltiness, flavor, and total acceptability compared to the other treatments ($p<0.05$). Among the treatments with mixed vegetable oils, the more content of olive oil, the lower score in flavor and total acceptability. These results were agreed with the report of Bloukas *et al.* (1997) which has negative effects on sensory characteristics by addition of olive oil.

Effect of replacing pork fat with vegetable oils on the fatty acid composition of emulsion-type pork sausages

The result of the comparison of fatty acid composition in emulsion-type pork sausages in which pork fat was

Table 4. Effect of replacing pork fat with vegetable oils on texture profile analysis of emulsion-type pork sausages*

Items	Hardness (g)	Cohesiveness (%)	Springiness (%)	Chewiness (g)
T1	437.00±22.06^{a}	42.51±8.77^{a}	56.04±12.38^{a}	177.94±7.71^{a}
T2	426.50±39.58^{a}	32.49±5.31^{b}	41.84±7.22^{c}	65.63±10.96^{b}
T3	237.00±45.65^{c}	33.88±5.07^{b}	42.99±8.13^{bc}	60.54±3.67^{b}
T4	305.25±25.61^{b}	43.16±8.93^{a}	49.25±7.46^{ab}	68.08±9.96^{b}
T5	320.60±34.50^{b}	33.88±7.69^{b}	37.70±8.56^{c}	28.66±7.42^{c}
T6	197.50±6.36^{c}	22.91±4.14^{c}	26.60±5.31^{d}	18.09±1.51^{c}

*Treatments are the same as in Table 1.
$^{a-d}$Means±SD with different superscript letters indicate significant differences ($p<0.05$).

Table 5. Effect of replacing pork fat with vegetable oils on sensory evaluation of emulsion-type pork sausages*

Items	Saltiness	Tenderness	Juiciness	Flavor	Total acceptability
T1	2.75±0.28^{a}	3.00±0.40	2.50±0.40	2.87±0.25^{a}	2.62±0.25^{a}
T2	2.50±0.40^{ab}	3.00±0.70	2.62±0.47	2.87±0.25^{a}	2.50±0.40^{ab}
T3	2.50±0.01^{ab}	2.87±0.25	2.62±0.47	2.75±0.28^{a}	2.62±0.25^{a}
T4	2.12±0.25^{bc}	2.87±0.25	2.50±0.57	2.37±0.47^{ab}	2.25±0.28^{ab}
T5	2.12±0.25^{bc}	2.87±0.25	2.25±0.28	2.37±0.25^{ab}	2.25±0.28^{ab}
T6	2.00±0.40^{c}	2.50±4.00	2.12±0.47	2.12±0.25^{b}	2.12±0.25^{b}

*Treatments are the same as in Table 1.
**1=not salty, very tough, very dry, very mild, very unacceptable, 5=very salty, very tender, very juicy, very intense, very acceptablity
$^{a-c}$Means±SD with different superscript letters indicate significant differences ($p<0.05$).

Table 6. Effect of replacing pork fat with vegetable oils on fatty acid composition of emulsion-type pork sausages*

	T1	T2	T3	T4	T5	T6
Myristic acid (C14:0)	1.11±0.12^{a}	0.65±0.00^{b}	0.19±0.01^{c}	0.26±0.00^{c}	0.19±0.00^{c}	0.19±0.00^{c}
Palmitic acid (C16:0)	21.08±0.76^{a}	15.15±0.82^{d}	17.92±0.28^{b}	16.35±0.17^{c}	17.44±0.39^{b}	17.34±0.22^{b}
Palmitoleic acid (C16:ln7)	2.25±0.21^{a}	1.50±0.00^{b}	0.54±0.03^{d}	0.76±0.01^{cd}	0.76±0.00^{cd}	0.78±0.22^{c}
Stearic acid (C18:0)	12.36±0.20^{a}	7.77±0.07^{b}	3.38±0.12^{d}	4.32±0.19^{c}	3.95±0.01^{c}	4.03±0.71^{c}
Oleic acid (C18:ln9)	46.59±0.40^{c}	52.50±0.45^{a}	49.34±2.02^{b}	51.72±0.58^{a}	52.65±0.21^{a}	48.16±0.88^{bc}
Linoleic acid (C18:2n6)	14.22±0.77^{c}	29.09±0.29^{b}	21.88±2.40^{a}	21.68±0.11^{a}	21.38±0.10^{a}	23.31±1.07^{a}
γ-Linoleic acid (C18:3n6)	0.06±0.01	0.04±0.00	1.73±2.96	0.05±0.00	0.05±0.00	0.04±0.00
Linolenic acid (C18:3n3)	0.95±0.22	2.03±0.01	4.02±2.67	3.82±0.06	2.75±0.20	5.25±0.15
Eicosenoic acid (C20:ln9)	1.04±0.04	0.92±0.02	0.76±0.52	0.84±0.01	0.63±0.00	0.65±0.30
Arachidonic acid (C20:4n6)	0.28±0.03^{a}	0.31±0.04^{a}	0.18±0.06^{b}	0.14±0.02^{b}	0.14±0.01^{b}	0.19±0.05^{b}
Saturated fatty acids	34.56±1.08^{a}	23.58±0.80^{b}	21.50±0.19^{c}	20.94±0.35^{c}	21.60±0.38^{c}	21.57±0.48^{c}
Unsaturated fatty acids	65.43±1.08^{c}	76.41±0.80^{b}	78.49±0.19^{a}	79.05±0.35^{a}	78.39±0.38^{a}	78.42±0.48^{a}
Mono unsaturated fatty acids	49.89±0.20^{b}	54.93±0.46^{a}	50.65±2.44^{b}	53.34±0.55^{a}	54.05±0.22^{a}	49.61±0.80^{b}
Ploy unsaturated fatty acids	15.53±0.95^{d}	21.48±0.33^{c}	27.83±2.33^{a}	25.71±0.20^{b}	24.34±0.19^{b}	28.81±1.24^{a}
n3	0.95±0.22^{e}	2.03±0.01^{d}	5.54±0.56^{a}	3.82±0.06^{b}	2.75±0.20c	5.25±0.15^{a}
n6	14.58±0.73^{d}	19.44±0.33^{c}	21.32±2.87^{bc}	21.88±0.14^{ab}	21.58±0.12^{ab}	23.55±1.09^{a}
n6/n3	15.76±0.33^{a}	9.55±0.17^{b}	3.88±0.91^{d}	5.72±0.05^{cd}	7.87±0.57^{bc}	4.47±0.08^{d}

*Treatments are the same as in Table 1.
$^{a-e}$Means±SD with different superscript letters indicate significant differences (p<0.05).

replaced with vegetable oils is shown in Table 6. In general, the addition of mixed vegetable oils significantly (p<0.05) increased unsaturated fatty acids (oleic acid and linoleic acid) and decreased saturated fatty acids (palmitic acid and stearic acid) in emulsion-type pork sausages. Additionally, the omega-3 and omega-6 fatty acid content in emulsion-type pork sausages was increased by the addition of mixed vegetable oils. Similar results were observed in study by Asuming-Bediako *et al.* (2014). According to Codex standards, olive oil contains 55-85% oleic acid and 3.5-21% linoleic acid, grape seed oil contains 12-28% oleic acid and 58-78% linoleic acid, and canola oil contains 8-60% oleic acid and 11-23% linoleic acid. Therefore, the higher unsaturated fatty acid content of vegetable oils increased the unsaturated fatty acid content of emulsion-type pork sausage.

Conclusion

Commercially available blended vegetable oil was used as a substitute for pork fat in the production of emulsion-type pork sausage. Vegetable oil replacement increased (p<0.05) WHC. The cholesterol in pork sausages tended to be decreased by vegetable oil substitution. The hardness, springiness, and chewiness values of pork sausages also decreased (p<0.05) when vegetable oils replaced pork fat. The emulsion-type pork sausage treated with blended vegetable oil showed overall similar properties and a soft texture compared with those of sausage containing pork fat. Thus, replacing pork fat with vegetable oils in the processing of emulsion-type pork sausages had no negative effects on quality properties and due to a reduction in saturated fatty acid ratio, resulted in the quality characteristics of the healthy meat products desired by consumers.

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