Quality characteristics of emulsion-type sausage made from spent layer meat with canola and flaxseed oil

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Abstract – The objective of this study was to identify the effects of canola and flaxseed oil on the physicochemical properties and sensory quality of spent layer sausages. Three types of emulsion-type spent layer sausages were made; control (20% pork back fat), CA (20% canola oil), and FL (20% flaxseed oil). Proximate composition showed significant ($p<0.05$) differences on the moisture and fat content among the samples. In the case of the pH value and cooking loss, there were no remarkable differences among the samples. CA led to higher water holding capacity and texture profile ($p<0.05$) than control. Furthermore, replacement of pork back fat with canola and flaxseed oil significantly increased the omega-3 fatty acid content ($p<0.05$). CA and FL sausage had significantly ($p<0.05$) lower saturated fatty acids composition and omega-6 to omega-3 ratio compared with control. As a result, using canola or flaxseed oil could form a sausage with physical quality attributes as well as using pork back fat with healthier fatty acid composition.

Key Words –Fatty acid composition, healthy meat products, omega-3

I. INTRODUCTION

Many researchers are working to optimize using spent layer because of their depreciation. The disposal of spent layers is one of the biggest economical and environmental problems of the poultry industry [1]. Therefore, we should add value to the spent layer to provide commercial value for the poultry industry.

Numerous researchers concerned about dietary habits of our contemporaries and nowadays consumers are increasingly interested in foods that not only palatability but also confer health benefits. But many traditional meat products such as sausage, ham, and bacon contain up to 30% fat. High fat intake is related to hypertension, cardiovascular disease, and obesity because of the fatty acid content [2]. In this case, fatty acid content means the amount of saturated fatty acid and omega-6 to omega-3 ratio. Therefore, one of the most important thing of developing healthier meats and meat products is to design foods that reduce the concentration of unhealthy contents and improve the healthy contents. These are mainly dependent to type of raw material.

Canola and flaxseed oil are very rich in polyunsaturated fatty acids, especially alpha-linolenic acid (an omega-3 fatty acid), and also highest PUFA to SFA ratio [3]. The objective of this study was adding value to the spent layers by replacing animal fat with plant oil, so that they could result in healthier products.

II. MATERIALS AND METHODS

Materials

Chicken breasts (spent layer; Hy-line®; 70 weeks old) were purchased from Jung-Woo-Food Agricultural Company (Korea). Pork back fat was purchased from a local processor. Canola oil was purchased from a local market and Flaxseed oil was purchased from SSAM-G-FNB Organic Product Company (Korea).

Sausages preparation

Chicken breast meat and pork back fat were initially ground through a 6-mm plate. Emulsion sausages were produced with the formulation given in Table 1. Three batches (each 1.2 kg) were prepared for each treatment. Chicken breast was emulsified with other ingridients in a silent cutter (OMF-500, Ohmichi, Japan). The batters were stuffed into collagen casings (#260, Nippi Collagen Ind., Japan; 26-mm diameter) using a stuffer (DK-9, F. Dick, Germany), boiled at 80°C for 1 h in a water bath (BW-20G, Lab.

Companion, Korea). The emulsion sausages were cooled by immersing in cold water for 30 min and dried at 4°C for 1 h. After drying, the emulsion sausage was vacuum-packed and stored at 4°C until analysis.

Table 1 Formulation of emulsion sausage

Ingredients (%)	Treatments		
	Control	CA	FL
Chicken breast	60	60	60
Pork back fat	20	0	0
Canola oil	0	20	0
Flaxseed oil	0	0	20
Ice	20	20	20
Total	100	100	100
Salt	1.50	1.50	1.50
Curing salt	0.30	0.30	0.30
FOS/ENR	0.30	0.30	0.30
Bologna seasoning	0.50	0.50	0.50
Beef powder	0.50	0.50	0.50
Sugar	0.50	0.50	0.50
Black pepper	0.10	0.10	0.10
Chopped onion	0.50	0.50	0.50
Potato starch	4.00	4.00	4.00
Smoke solution	0.05	0.05	0.05
ISP	1.00	1.00	1.00

Control: spent layer sausage with pork back fat; CA: spent layer sausage with canola oil; FL: spent layer sausage with flaxseed oil; Curing salt: 93.1% salt, 5.9% sodium nitrite, and 1.0% sodium carbonate; FOS/ENR: 40% sodium polyphosphate, 30% sodium pyrophosphate dehydrate, and 30% acid sodium pyrophosphate; ISP: Isolated soy protein.

Moisture, crude fat, color & pH evaluation

Moisture and fat were assayed using Association of Official Analytical Chemists [4]. The instrumental color was recorded by measuring CIE lightness (L*), redness (a*) and yellowness (b*) using a chromameter (CR-400, Konica Minolta Sensing Inc., Japan). The pH value of the homogenized samples were recorded using a pH meter (SevenEasy pH, Mettler-Toledo GmbH, Switzerland).

Cooking loss & emulsion stability

Three 4-cm diameter and 2-cm height samples (weight 100 ± 0.8 g) reshaped from meat batters were placed in a polypropylene bag and boiled in a water bath at 80°C for 30 min. Cooking loss was determined by calculating the weight differences before and after boiling. Emulsion stability of the different samples was determined in triplicate according to the procedure described by Kim *et al* [6].

Texture profile analysis (TPA)

TPA was performed at room temperature with a texture analyzer (TA-XT2i, Stable Micro Systems Ltd., England). 1 × 1 × 1 cm^3 (width × length × height) samples taken from the central portion of each emulsion sausage were kept to equilibrate to room temperature. The texture analysis conditions were as follows: pre-test speed 2.0 mm/s, post-test speed 5.0 mm/s, maximum load 5 kg, head speed 2.0 mm/s and distance 8.0 mm.

Fatty acid composition

Fatty acid composition was determined using a gas chromatography (YL6500, YL Instrument, Korea). The lipid fraction of the sausages, extracted according to Folch *et al.* [5] and methylated as described by AOAC [4]. Fatty acid methyl esters were separated using an Omegawax-320 fused silica capillary column (30 m × 0.32 mm i.d., 0.25 μm film thickness; Supelco, Inc., USA). The fatty acid peaks were identified and quantified by comparing with the retention time and peak area of fatty acids standard mixtures (Supelco 47015-U).

Statistical analysis

Data were subjected to one-way ANOVA using R-version 3.1.2 with "Agricolae" library (The R-foundation for Statistical Computing, Austria). The statistical significance of the differences between means from different treatments was determined by Duncan's multiple range test ($p \leq 0.05$).

III. RESULTS AND DISCUSSION

The proximate composition values of treatments are shown in Table 2. The moisture content of the Control was the highest among the samples. However, the fat content was the highest at CA ($p<0.05$). This result had analogical tendency as adding dietary fiber [5].

The pH of the sausage was a little higher than the meat batter sample. But there were no remarkable differences among all samples. Furthermore, in the

case of the cooking loss, there were no significant differences among treatments. However, water holding capacity was the highest at CA ($p<0.05$). Therefore, it is possible to say that using canola and flaxseed oil as a pork fat replacement can form emulsion stability as much as pork fat.

Table 2 Physicochemical properties of spent layer sausages made with canola and flaxseed oil compared with control

Traits	Treatments			SEM
	Control	CA	FL	
Moisture (%)	64.08 [a]	60.98 [c]	62.45 [b]	0.38
Crude Fat (%)	14.08 [b]	17.53 [a]	11.59 [c]	0.75
pH				
Meat batter	6.22	6.21	6.22	0.01
Sausage	6.29	6.43	6.46	0.05
Emulsion stability				
Water loss (ml/g)	3.35	2.44	5.37	0.69
Fat loss (ml/g)	2.32	2.68	2.45	0.12
Cooking loss (%)	3.47	2.46	3.47	0.22
Meat batter				
Lightness (*L**)	75.32 [c]	83.51 [a]	80.87 [b]	0.64
Redness (*a**)	2.73 [b]	2.95 [a]	-0.62 [c]	0.31
Yellowness (*b**)	12.21 [b]	11.43 [c]	29.21 [a]	1.53
Sausage				
Lightness (*L**)	78.85 [c]	82.33 [a]	80.43 [b]	0.42
Redness (*a**)	3.06 [a]	3.24 [a]	0.17 [b]	0.38
Yellowness (*b**)	10.49 [b]	10.76 [b]	26.94 [a]	2.07
Hardness (kg)	3.58 [b]	5.69 [a]	2.87 [b]	0.32
Springiness (cm)	0.72 [b]	0.91 [a]	0.88 [a]	0.02
Cohesiveness	0.22 [b]	0.27 [a]	0.28 [a]	0.01

SEM, standard error of the means; [a-c] means within each row with different superscripts are significantly different ($p<0.05$)

Lightness (*L**) and redness (*a**) of CA were significantly higher than other samples. FL samples showed the highest yellowness (*b**) because flaxseed oil has deep yellow color ($p<0.05$).

The effects of canola and flaxseed oil on the textural properties of emulsion sausage are also given in Table 2. The hardness of the CA was the highest ($p<0.05$). The springiness and cohesiveness of CA and FL were higher than that of control ($p<0.05$). These results showed that canola oil, which was kept high quality water holding capacity, could make emulsion well, and it was related to develop better texture.

The fatty acid composition of treatments is given in Table 3. CA and FL showed significantly lower values for saturated fatty acid content and omega-6 to omega-3 ratio ($p<0.05$). The recommendation of PUFA/SFA ratios more than one can maintain well-balanced health status [6]. In this study, we could obtain PUFA/SFA ratios up to 4 for both CA and FL ($p<0.05$). That means, by using canola and flaxseed oil as an animal fat replacement have high potential in the manufacture healthier product.

Table 3 Fatty acid composition (%) of spent layer sausages made with canola and flaxseed oil compared with control

Fatty acid	Treatments			SEM
	Control	CA	FL	
C14:0	1.39 [a]	0.00 [b]	0.01 [b]	0.23
C16:0	34.01 [a]	5.19 [b]	6.12 [b]	4.75
C16:1n-7	1.75 [a]	0.02 [b]	0.01 [b]	0.29
C18:0	26.11 [a]	0.80 [b]	4.93 [b]	3.98
C18:1n-9	27.46	66.34 [b]	30.39 [a]	6.31
C18:2n-6	8.49 [c]	20.20 [a]	16.05 [b]	1.73
C18:3n-6	0.08 [a]	0.01 [b]	0.01 [b]	0.01
C18:3n-3	0.46 [c]	7.15 [b]	42.33 [a]	6.50
C20:1n-9	0.04	0.02	0.03	0.01
C20:4n-6	0.08 [a]	0.01 [b]	0.05 [c]	0.01
C20:5n-3	0.02	0.02	0.01	0.002
C22:4n-6	0.11 [a]	0.06 [b]	0.04 [c]	0.01
C22:6n-3	0.01 [b]	0.18 [a]	0.03	0.03
SFA	61.51 [a]	5.99 [b]	11.06 [b]	8.94
MUFA	29.24 [b]	66.38 [a]	30.42 [a]	6.16
PUFA	9.25 [c]	27.63 [b]	58.52 [a]	7.19
PUFA/SFA	0.15 [b]	4.80 [a]	5.30 [a]	0.84
n-3	0.49 [c]	7.35 [b]	42.38 [a]	6.49
n-6	8.75 [c]	20.28 [a]	16.14 [b]	1.70
n-6/n-3	17.70 [a]	2.78 [b]	0.38 [c]	2.72

SEM, standard error of the means;SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; UFA, unsaturated fatty acids; [a-c] means within each row with different superscripts are significantly different ($p<0.05$).

IV. CONCLUSION

Using canola and flaxseed oil as an animal fat replacement provides positive result on the physicochemical properties and fatty acid composition. It is suitable for modern people who have bad dietary habits, which is dependent too

much on the meat consumption. Further research is needed on the storage condition of these products because of their higher polyunsaturated fatty acid composition that may promote lipid oxidation.

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