EFFECT OF MIXING RATIO BETWEEN PORK BACK FAT AND CANOLA OIL ON PHYSICOCHEMICAL PROPERTIES OF EMULSION SAUSAGES FROM SPENT LAYER MEAT

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Abstract – The objective of this study was to identify the effects of mixing ratio between pork back fat and canola oil on physicochemical properties of spent layer sausages. Five different types of batches were prepared with mixing fat as follow ratios: 20 % pork back fat (T0; 100 / 0), 15 % pork back fat with 5 % canola oil (T1; 75 / 25), 10 % pork back fat with 10 % canola oil (T2; 50 / 50), 5 % pork back fat with 15 % canola oil (T3; 25 / 75), and 20 % canola oil (T4; 0 / 100). For emulsion stability, no significant differences were found among samples ($p>0.05$). T3 and T4 showed higher lightness value than others ($p<0.05$). The shear force of the T3 and T4 showed significantly higher than other treatments ($p<0.05$), and T2 had the highest hardness value ($p<0.05$). The more intensive canola oil gives less SFA and omega-6 to omega-3 ratio ($p<0.05$), while the results of polyunsaturated fatty acids (PUFA) and oleic acid content (C18:1n-9) showed reversed pattern ($p<0.05$). As a result, using canola oil could form emulsion stability as much as pork fat, and had high potential in the manufacturing healthier product.

Key Words – Emulsion stability, fatty acid composition, texture profile

I. INTRODUCTION

The consumption of spent layer as partial meat resources has increased [1]. Many researchers have been making an effort to optimize the use of spent layer because of their depreciation. Therefore, adding value to the spent layer to provide commercial value for the poultry industry is important. Nowadays, consumers demand healthier foods because of various diseases which depend on the amount of fat materials or the type of fat sources. The reduction of animal fat through the use of non-meat materials, for example dietary fiber or vegetable oils, has the possibility to produce healthier meat products. Canola oil contains a high amount of omega-3 fatty acids [2], and these can help reducing rates of various diseases, such as diabetes and cardiovascular disease [3]. The objective of this study was to investigate the effects of mixing ratio between pork back fat and canola oil as fat resources on physicochemical properties in spent layer sausages to find ways to optimize the health ratings and spent layer products.

II. MATERIALS AND METHODS

Materials

Twenty spent layer breasts (Hy-line; 75 weeks old) were purchased from JUNG-WOO-FOOD Agricultural Co., Ltd. (Korea) and approximately 20 kg of pork back fats were purchased from a local meat shop. Fresh canola oil was purchased from a local market.

Emulsion sausages preparation

All subcutaneous and intramuscular fat and visible connective tissue were removed from the chicken breast. The chicken breast and pork back fat were initially ground through an 6-mm plate. Emulsion sausages were produced with the formulation is given in Table 1. Five batches were prepared for each treatment. Each T0 and T4 was prepared with 20 % pork back fat (100 / 0) and 20 % canola oil (0 / 100), respectively. The other treatments were prepared with mixing pork back fat and canola oil as follow ratios: 15% pork back fat with 5 %

canola oil (T1), 10 % pork back fat with 10 % canola oil (T2), and 5% pork back fat with 15 % canola oil (T3). Chicken breast was emulsified for 6 min in a silent cutter (OMF-500, Ohmichi Co., Ltd., Maebashi, Japan) with added iced water, 1.5 % salt, 0.3 % curing salt, and 0.3 % sodium tri-polyphosphate. Fat, 0.05 % sodium ascorbate, 0.2 % mono-sodium glutamate, 0.5% sugar, 0.2% black pepper and iced water were added to the batters and then mixed for 6 min. 4 % potato starch and iced water were added to the batters and then mixed for 4 min. For the meat batter experiment, the meat batter samples were stored at 4 °C in the dark and under vacuum conditions up until the analyses for color, pH, and emulsion stability. Another set of meat batter samples was filled into collagen casings (#260, Nippi Collagen Ind., Tokyo, Japan; 26-mm diameter) using a sausage filler (DK-9, Friedr. Dick GmbH & Co. KG, Deizisau, Germany). They were then heated to 80 °C for 30 min in a water bath (BW-20G, Jeio Tech Co., Daejon, Korea). The emulsion sausage products were cooled with cold running water for 30 min and dried at 4 °C for 1 h. After drying, the products were stored at 4 °C in the dark and under vacuum conditions until quality analyses.

Table 1 Formulation of spent layer sausages mixing with different pork back fat and canola oil ratios

Ingredients (%)	Treatments				
	T0	T1	T2	T3	T4
Spent layer breast	60	60	60	60	60
Pork back fat	20	15	10	5	-
Canola oil	-	5	10	15	20
Ice	20	20	20	20	20
Total	100	100	100	100	100
Salt	1.5	1.5	1.5	1.5	1.5
Curing salt	0.3	0.3	0.3	0.3	0.3
Sodium tri-polyphosphate	0.3	0.3	0.3	0.3	0.3
Sodium ascorbate	0.05	0.05	0.05	0.05	0.05
Mono-sodium glutamate	0.2	0.2	0.2	0.2	0.2
Sugar	0.5	0.5	0.5	0.5	0.5
Black pepper	0.2	0.2	0.2	0.2	0.2
Potato starch	4	4	4	4	4

Curing salt: 93.1% salt, 5.9% sodium nitrite, and 1.0% sodium carbonate.

Color evaluation

The surface color of each emulsion sausage was determined by using chroma-meter (CR-400, Konica Minolta Sensing Inc., Osaka, Japan) measuring lightness (CIE L*-value), redness (CIE a*-value) and yellowness (CIE b*-value); illuminate C was calibrated with a white standard plate (Y= 93.6, X=0.3134, y= 0.3194).

pH

A homogenizer (PH-91, SMT Co., Japan) was used to homogenize 5 g of sample in 50 mL of distilled water for 1 min at 10,000 rpm. The pH values were recorded using a pH meter (SevenEasy pH, Mettler-Toledo GmbH, Schwerzenbach, Switzerland).

Cooking loss

Three uncooked sausages (weight 70 ± 10 g) were placed in a polypropylene bag and cooked using a water bath at 80°C for 30 min. These samples were cooled to room temperature for 30 min, and cooking loss was determined by calculating the weight differences before and after cooking.

Emulsion stability

The emulsion stability was measured in triplicate using the Choi *et al.* [4] method and Laakkonen *et al.* [5] method with slight modifications. First, a sieve (4 × 4 cm, 19 mesh) was put in the middle of a specially formed centrifuge tube. Approximately 10 g of meat batter samples were then placed on the sieve, and covered with aluminum foils. Samples were cooked at 75 °C for 30 min in a water bath and then centrifuged at 1,000 rpm for 10 min at 4 °C. Each water and fat layer was measured using tube gradation and then calculated.

Texture profile analysis (TPA)

TPA was performed at room temperature with a texture analyzer TA1 (LLOYD materials testing, AMETEK Inc., UK). 1 × 1 × 1 cm (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: trigger speed 2.0 mm/s, maximum load 2 kg, head speed 1.0 mm/s, distance 8.0 mm, force 10 gf.

Fatty acid composition

Fatty acid composition was determined using a gas chromatography (YL6500, YL Instrument, Korea). The lipid fraction of the meat sample, extracted according to Folch *et al.* [6] with chloroform-methanol (2:1 v/v). Samples were methylated as described by AOAC [7]. One μL of sample was injected into the column in the split mode (100:1). Fatty acid methyl esters were separated using a Wcot fused silica capillary column (#CP7489, 100 m × 0.25 mm i.d., 0.2 μm film thickness; Varian, Inc., USA) with a 1 mL/min of helium flow. The oven temperature was increased; 150 to 200 °C at 15 °C/min, 200 to 250 °C at 5 °C/min. Temperatures of the injector and detector were 275 °C. The fatty acid peaks were identified and quantified by comparing with the retention time and peak area of fatty acid standards (Supelco 47015-U, USA).

Statistical analysis

Other 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 ($p<0.05$).

III. RESULTS AND DISCUSSION

The results of the physicochemical properties among samples are presented in Table 2. T0 and T1, which prepared with mixing pork back fat and canola oil as 100 / 0 and 75 / 25 respectively, showed significantly higher cooking loss than for the other treatments ($p<0.05$). However, for emulsion stability, no significant differences were found among samples ($p>0.05$). The pH value of the T0 was significantly lower than other treatments ($p<0.05$). In case of lightness (L*), T3 and T4 showed higher value than others ($p<0.05$), and T0 showed the lowest lightness value. For canola oil, the more we use, the brighter we get. However, the results for redness (a*) showed a reversed pattern ($p<0.05$). The yellowness of the T2 showed significantly higher than for the other treatments ($p<0.05$). For overall texture profile, T0 showed the lowest value ($p<0.05$). The shear force of the T3 and T4 showed significantly higher than other treatments ($p<0.05$), and T2 had the highest hardness value ($p<0.05$). Using up to 50 % canola oil gives significantly high chewiness value ($p<0.05$).

Table 2 A comparison of physicochemical properties of spent layer sausages mixing with different pork back fat and canola oil ratios

Traits	Treatments					SEM
	T0	T1	T2	T3	T4	
Cooking loss (%)	5.07^{a}	5.18^{a}	4.78^{b}	4.41^{c}	4.85^{b}	0.09
E. stability						
Water loss (%)	3.40	3.33	3.49	3.97	3.96	0.14
Fat loss (%)	2.63	2.99	2.66	2.65	2.47	0.14
pH	6.14^{c}	6.16^{a}	6.11^{d}	6.15^{b}	6.16^{a}	0.01
CIE L*	79.3^{c}	82.3^{b}	82.5^{b}	84.9^{a}	85.4^{a}	0.34
CIE a*	1.61^{a}	1.56^{a}	1.64^{a}	1.30^{b}	0.81^{c}	0.05
CIE b*	8.85^{c}	9.80^{b}	10.3^{a}	8.99^{c}	9.87^{b}	0.10
Shearforce (kgf)	0.42^{b}	0.47^{ab}	0.46^{ab}	0.48^{a}	0.49^{a}	0.01
Hardness (kg)	2.14^{b}	2.59^{ab}	3.03^{a}	2.56^{ab}	2.70^{ab}	0.09
Chewiness	0.77^{b}	0.87^{b}	1.06^{a}	1.05^{a}	1.07^{a}	0.03

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

The fatty acid profile of treatments is given in Table 3. The highest saturated fatty acids (SFA) were observed in T0 ($p<0.05$). The more intensive canola oil gives less SFA and omega-6 to omega-3 ratio ($p<0.05$), while the results of polyunsaturated fatty acids (PUFA) and oleic acid content (C18:1n-9) showed reversed pattern ($p<0.05$).

Table 3 Fatty acid composition of spent hen sausages with different canola oil ratios

Fatty acid	Treatments					SEM
	T0	T1	T2	T3	T4	
C14:0	1.87^{a}	1.47^{b}	1.00^{b}	0.53^{b}	0.10^{b}	0.17
C16:0	24.4^{a}	20.3^{b}	15.5^{c}	10.4^{d}	5.60^{e}	1.80
C16:1n-7	1.77^{a}	1.63^{a}	1.10^{b}	0.70^{c}	0.30^{d}	0.15
C18:0	12.4^{a}	10.3^{b}	7.63^{c}	4.90^{d}	2.40^{e}	0.97
C18:1n-9	38.3^{e}	44.1^{d}	48.9^{c}	54.4^{b}	59.4^{a}	2.00
C18:2n-6	18.9^{d}	18.2^{e}	19.6^{c}	20.5^{b}	21.7^{a}	0.34
C18:3n-6	0.80^{e}	1.00^{d}	1.10^{c}	1.20^{b}	1.30^{a}	0.05
C18:3n-3	0.90^{e}	2.63^{d}	4.63^{c}	6.73^{b}	8.80^{a}	0.75
C20:4n-6	0.50^{a}	0.40^{b}	0.40^{b}	0.30^{c}	0.27^{c}	0.02
C20:5n-3	0.00^{c}	0.03^{c}	0.10^{b}	0.10^{b}	0.20^{a}	0.02
SFA	38.7^{a}	32.1^{b}	24.2^{c}	15.9^{d}	8.10^{e}	2.93

UFA	61.2^{e}	68.0^{d}	75.9^{c}	84.0^{b}	92.0^{a}	2.94
MUFA	40.1^{e}	45.7^{d}	50.0^{c}	55.1^{b}	59.7^{a}	1.85
PUFA	21.1^{e}	22.2^{d}	25.9^{c}	28.9^{b}	32.3^{a}	1.11
PUFA/SFA	0.55^{e}	0.69^{d}	1.07^{c}	1.82^{b}	3.98^{a}	0.34
n-3	0.90^{e}	2.67^{d}	4.73^{c}	6.83^{b}	9.00^{a}	0.77
n-6	20.2^{d}	19.6^{e}	21.1^{c}	22.0^{b}	23.3^{a}	0.36
n-6/n-3	22.4^{a}	7.34^{b}	4.47^{c}	3.22^{d}	2.59^{e}	1.98

SEM, standard error of the means; [a-d] means within each row with different superscripts are significantly different (p<0.05).
[1] T0: spent layer sausage with pork back fat; T1: spent layer sausage with mixing pork back fat and canola oil as 75/25; T2: spent layer sausage with mixing pork back fat and canola oil as 50/50; T3: spent layer sausage with mixing pork back fat and canola oil as 25/75; T4: spent layer sausage with mixing pork back fat and canola oil as 0/100.

IV. CONCLUSION

For mixing pork back fat with canola oil, no differences are found in emulsion stability. Moreover, using canola oil more than 50 % of total fat not only shows lower cooking loss but also appears tight texture than for the other treatments. The more intensive canola oil as fat material could help to form ideal ratios of PUFA to SFA and omega-6 to omega-3 fatty acids.

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