Effect of Substituting Pork Fat with Sunflower Seed Oil and *Makgeolli* Lees Fiber on Quality Characteristics of Reduced-fat Emulsion Sausage

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***Abstract*— The effects of reducing pork fat levels from 30% to 20% by partially substituting fat with a mix of sunflower seed oil and *makgeolli* lees fiber were investigated based on quality characteristics of reduced-fat chicken emulsion sausages. The moisture and ash content were higher in reduced-fat emulsion sausage samples containing sunflower seed oil and *makgeolli* lees fiber than in the control. The results showed that reduced-fat emulsion sausage samples with higher sunflower seed oil levels had lower cooking loss, emulsion stability, hardness, springiness, and apparent viscosity. The results of this study show that incorporating sunflower seed oil and *makgeolli* lees fiber into the formulation successfully reduced-fat in emulsion sausages, while improving quality characteristics.**

Keywords— ***makgeolli* lees fiber, sunflower seed oil, emulsion sausage.**

I. INTRODUCTION

Fat is an important constituent of processed meat products because it affects the stabilization of meat emulsions, reduces cooking losses, improves water holding capacity, provides flavor, texture, tenderness, juiciness, and a desired mouth feel [1]. However, consuming high amounts of saturated fatty acids and cholesterol in meat products leads to high animal fat consumption [2]. High saturated fatty acid and cholesterol intake is associated with obesity, hypertension, cardiovascular disease, and coronary heart disease [3]. Sunflower (*Helianthus annuus*) seed oil is an excellent source of essential fatty acids such as oleic acid and linoleic acid required by the human body; thus, lowering cardiovascular disease risk [4]. The advantage of sunflower seed oil is its higher oxidative stability than oils low in oleic acid, which is desirable for refining and storage [5]. *Makgeolli* is one of the most popular alcoholic drinks in Korea, which is brewed by conventional methods using *nuruk* or *koji* [6]. Thus, a large amount of *makgeolli* lees is produced annually in Korea. The by-products of *makgeolli* brew processing are ordinarily used as animal feed or fertilizers, but some *makgeolli* lees are wasted. Moreover, *makgeolli* lees contains dietary fiber, proteins, minerals, vitamins, and organic acids required for human health. In particular, the major component of *makgeolli* lees is dietary fiber, but utilizing *makgeolli* lees in commercial products has so far been limited.

The objective of this study was to evaluate how replacing animal fat with various levels of sunflower seed oils emulsified with *makgeolli lees* fiber optimizes quality characteristics of reduced-fat emulsion sausages.

II. MATERIALS AND METHODS

2.1. Preparation and processing of makgeolli lees fiber extract

Dietary fiber was extracted using the modified AOAC enzymatic-gravimetric method (AOAC, 2000).

2.2. Sunflower seed oil emulsified preparation

The sunflower (*Helianthus annuus*) seed oil used to replace pork back fat was obtained from a local market. It was emulsified on the day of use with eight parts hot water and mixed for 2 min with one part isolated soy protein.

2.3. Emulsion sausage preparation and processing

Fresh chicken breast meat (*M. pectoralis major*) and pork back fat (moisture 12.61%, fat 85.64%) were purchased from a local processor. The chicken breast meat and pork fat were initially ground through an 8-mm plate. The first meat batter served as the control and was prepared with 30% pork back fat. The concentration of the *makgeolli* lees fiber and back fat

was determined by Choi et al. [6]. The second meat batter (T1) was prepared with 20% pork back fat and 2% *makgeolli* lees fiber. The next three meat batters were prepared with pre-emulsified sunflower seed oil. The following combinations of sunflower seed oil, back fat, and *makgeolli* lees fiber were used; T2: pork back fat 15% + sunflower seed oil 5% + *makgeolli* lees fiber 2%; T3: pork back fat 10% + sunflower seed oil 10% + fiber 2%; T4: pork back fat 5% + sunflower seed oil 15% + fiber 2%; T5: sunflower seed oil 20% + fiber 2%. Chicken breast meat was homogenized, ground for 1 min in a silent cutter, then chilled in iced water (2˚C). NaCl (1.5%), sodium tripolyphosphate (0.3%), sodium nitrite (0.01%), and sugar (0.5%), were added to the meat and mixed for 1 min. *Makgeolli* lees fiber (2%) was used for the samples and pork back fat or pre-emulsified sunflower seed oil was added after 3 min. The chicken meat batters were homogenized for 5 min. After emulsification, the meat batter was stuffed into collagen casings using a stuffer. The meat batters were then heated to 75˚C for 30 min in a water bath, and then the cooked meat batters were cooled in cold water (15˚C).

2.4. Proximate composition

Compositional properties of the emulsion sausages were determined using AOAC (2000).

2.5. Cooking loss

The meat batters were stuffed into the casing (initial weight) and after heat processing at 75 ℃ for 30 min, cooked samples were cooled to room temperature at 21℃ for 3 h. After cooling, the cooked meat batter was weighed and the cooking loss was calculated from the weights.

2.6. Emulsion stability

The samples of meat batter were analyzed for emulsion stability using the method of Blouka and Honikel (1992) with the following modifications.

2.7. Apparent viscosity

Meat batter viscosity was measured in triplicate with a rotational viscometer set at 10 rpm. The standard cylinder sensor was positioned in a 25 ml metal cup filled with batter and allowed to rotate under a constant share rate (s^{-1}) for 60 s before each reading was taken.

2.8. Texture profile analysis

Texture profile analysis (TPA) was performed at room temperature with a texture analyzer (TA-XT2*i*, Stable Micro Systems Ltd., Surrey, England).

2.9. Statistical analysis

An analysis of variance was performed on all the variables measured using the general linear model procedure of the SAS statistical package (1999). Duncan's multiple range test ($P < 0.05$) was used to determine the differences among treatments.

III. RESULTS AND DISCUSSIONS

The proximate composition of the reduced-fat meat sausages formulated with different amounts of sunflower seed oil and 2% *makgeolli* lees fiber are given in Table 1. The differences in moisture, protein, fat, ash, and digested carbohydrate content of the reduced-fat emulsion sausages were statistically significant compared to the control. The cooking loss of the reduced-fat meat emulsion sausages with various concentrations of sunflower seed oil and 2% *makgeolli* lees fiber are shown in Table 2. The reduced-fat chicken meat emulsion sausages with sunflower seed oil and 2% *makgeolli* lees fiber (T2, T3, T4, and T5) had less cooking loss compared to controls with a pork back fat content of 30%. The cooking loss was lowest in the emulsion sausage treatments with 20% added sunflower seed oil and 2% *makgeolli* lees fiber (T5). The differences in emulsion stability of the raw meat batters formulated with sunflower seed oil at different concentrations and with 2% *makgeolli* lees fiber were significant. The control had the highest fat loss and total expressible fluid but the lowest emulsion stability. Increasing the sunflower seed oil levels from 0% to 20% significantly decreased fat loss and total expressible fluid. Substituting different sunflower seed oil levels and adding *makgeoli* lees fiber affected the apparent viscosity of the reduced-fat emulsion batters (Fig. 1). The control and batter treatments in which pork back fat was replaced with sunflower seed oil and *makgeoli* lees

Table 1. Proximate composition of reduced-fat emulsion sausage formulations with varying percentages of added sunflower seed oil and *makgeolli* lees fiber

Trait	Treatments[A]					
	Control	T1	T2	T3	T4	T5
Moisture (%)	48.83 ±0.84[b]	58.80 ±2.70[a]	57.75 ±2.12[a]	59.59 ±1.31[a]	58.65 ±1.07[a]	58.72 ±2.08[a]
Protein (%)	19.25 ±0.31[a]	16.54 ±0.18[b]	16.45 ±0.16[b]	15.82 ±0.11[c]	15.44 ±0.25[c]	14.57 ±0.42[d]
Fat (%)	30.44 ±0.84[a]	22.00 ±0.78[b]	22.06 ±0.85[b]	21.87 ±0.92[b]	22.54 ±0.88[b]	22.73 ±0.91[b]
Ash (%)	1.89 ±0.07[b]	1.96 ±0.05[a]	1.92 ±0.04[a]	1.99 ±0.14[a]	1.95 ±0.03[a]	1.95 ±0.04[a]

All values are mean ± standard deviation of three replicates
[a-d] Means within a row with different letters are significantly different ($P < 0.05$).
[A] Control: pork back fat (30%), T1: pork back fat (20%) + *makgeolli* lees fiber (2%), T2: pork back fat (15%) + sunflower seed oil (5%) + *makgeolli* lees fiber (2%), T3: pork back fat (10%) + sunflower seed oil (10%) + *makgeolli* lees fiber (2%), T4: pork back fat (5%) + sunflower seed oil (15%) + *makgeolli* lees fiber (2%), T5: sunflower seed oil (20%) + *makgeolli* lees fiber (2%).

Table 2. Effects of various percentages of added sunflower seed oil and *makgeolli* lees fiber on cooking loss and emulsion stability of reduced-fat emulsion sausage formulations

Traits	Treatments[A]					
	Control	T1	T2	T3	T4	T5
Cooking loss	18.40 ±2.00[a]	19.79 ±0.65[a]	18.85 ±0.76[b]	17.26 ±1.25[b]	14.88 ±0.97[c]	11.28 ±1.35[d]
Emulsion stability						
Fat loss (ml/ 100 g)	4.87 ±0.35[a]	2.01 ±0.02[b]	1.94 ±0.74[c]	1.92 ±0.50[c]	1.88 ±0.29[c]	1.68 ±0.77[d]
Total expressible fluid (ml/100 g)	10.88 ±1.56[a]	10.67 ±0.64[a]	8.15 ±0.05[b]	7.48 ±0.09[bc]	6.52 ±0.24[c]	5.68 ±0.35[d]

All values are mean ± standard deviation of three replicates
[a-d] Means within a row with different letters are significantly different ($P < 0.05$).
[A] Treatments are the same as in Table 1.

fiber were thixotropic, with apparent viscosity values that decreased with rotation time. The sunflower seed oil level and added *makgeolli* lees fiber significantly affected the textural properties of the reduced-fat emulsion sausages (Table 3). The hardness was higher in the control with 30% added pork back fat compared to treatments with 20% added fat and *makgeoli* lees fiber. The treatments with 20% sunflower seed oil and 2% *makgeoli* lees fiber had the lowest hardness. Treatments with sunflower seed oil and *makgeoli* lees fiber had significantly lower springiness, gumminess, and chewiness than those of the control.

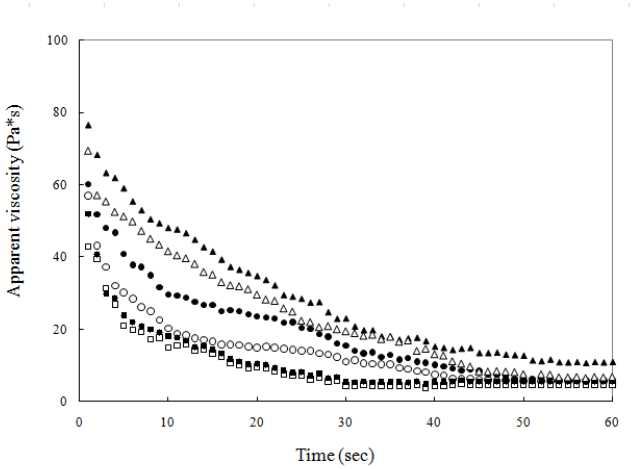

Fig.2. Changes in apparent viscosity of meat batters containing various percentages of added sunflower seed oil and *makgeolli* lees fiber stirred for 1 min. (▲) Control, (△) T1, (●) T2, (○) T3, (■) T4, (□) T5: Treatments are the same in Table 1.

Table 3. Effects of various percentages of added sunflower seed oil and *makgeolli* lees fiber on the textural attributes of reduced-fat emulsion sausage formulations

Traits	Treatments[A]					
	Control	T1	T2	T3	T4	T5
Hardness (N)	3.47 ±0.33[a]	3.04 ±0.22[c]	3.06 ±0.20[c]	3.14 ±0.40[bc]	3.23 ±0.22[b]	2.99 ±0.20[d]
Springiness	0.92 ±0.05[a]	0.91 ±0.02[ab]	0.91 ±0.04[ab]	0.90 ±0.04[ab]	0.87 ±0.03[bc]	0.87 ±0.05[bc]
Cohesiveness	0.52 ±0.03[b]	0.50 ±0.03[b]	0.52 ±0.02[b]	0.55 ±0.03[a]	0.56 ±0.03[a]	0.57 ±0.04[a]
Gumminess (N)	1.84 ±0.19[a]	1.45 ±0.14[b]	1.52 ±0.11[b]	1.73 ±0.31[b]	1.72 ±0.21[b]	1.71 ±0.11[b]
Chewiness (N)	1.68 ±0.18[a]	1.29 ±0.14[c]	1.39 ±0.09[bc]	1.48 ±0.26[b]	1.51 ±0.21[b]	1.49 ±0.16[bc]

All values are mean ± standard deviation of three replicates
[a-d] Means within a row with different letters are significantly different ($P < 0.05$).
[A] Treatments are the same as in Table 1.

IV. CONCLUSIONS

Reduced-fat emulsion sausages are beneficial for health, as they have improved physicochemical, emulsion stability, viscosity, and textural properties. The reduced-fat emulsion sausages formulated with sunflower seed oil and *makgeolli* lees fiber had sensory properties similar to regular-fat sausage (control). Therefore, incorporating sunflower seed oil and *makgeolli* lees fiber into the formulation successfully reduced animal fat in the emulsion sausages.

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REFERENCES

1. Choi Y S, Choi J H, Han D J et al. (2010) Effects of replacing pork back fat with vegetable oils and rice bran fiber on the quality of reduced-fat frankfurters. Meat Sci. 84:557-563.
2. Ozvural E B, Vural H. (2005) Utilization of interesterified oil blends in the production of frankfurters. Meat Sci. 78:211-216.
3. Choi Y S, Choi J H, Han D J et al. (2009) Characteristics of low-fat meat emulsion systems with pork fat replaced by vegetable oils and rice bran fiber. Meat Sci. 82:266-271.
4. Fuller M, Diamond J, Applewhite T. (1967) High oleic sunflower oil. Stability and chemical modification. J. AOCS. 44:264-267.
5. Pereyra-Irujo G A, Aguirrezabal L A N. (2007) Sunflower yield and oil quality interactions and variability: analysis through a simple simulation model. Agricul. Forest Meterol. 143:252-265
6. Choi Y S, Park K S, Choi J H et al. (2010) Physico-chemical properties of chicken meat emulsion systems with dietary fiber extracted from *makgeolli* lees. J. Korean Soc. Food Sci. Ani. Resour. 30:910-917.