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Physicochemical properties and sensory characteristics of reduced-fat frankfurters with pork back fat replaced by dietary fiber extracted from *makgeolli* lees

Yun-Sang Choi [a], Hyun-Wook Kim [b], Ko-Eun Hwang [b], Dong-Heon Song [b], Ji-Hun Choi [b], Mi-Ai Lee [c], Hai-Jung Chung [d], Cheon-Jei Kim [b,*]

[a] Food and Biological Resources Examination Division, Korean Intellectual Property Office, Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea
[b] Department of Food Science and Biotechnology of Animal Resources, Konkuk University, 1 Hwayang-dong, Gwangjin-gu, Seoul 143-701, Republic of Korea
[c] World Institute of Kimchi, An Annex of Korea Food Research Institute, 516, Baekhyun-dong, Bundang-Ku, Sungnam-Si, Gyeonggi-do 463-746, Republic of Korea
[d] Department of Food Science and Nutrition, Daejin University, Sundan-ri, Phochon-si, Gyeonggi-do 487-711, Republic of Korea

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ABSTRACT

The effects of reducing pork fat levels from 30% to 20%, 15%, and 10% by partially substituting pork back fat with a *makgeolli* lees fiber were investigated regarding approximate composition, energy value, pH, color, cooking loss, emulsion stability, texture profile analysis, apparent viscosity, and sensory evaluation. The moisture and ash contents, redness, and yellowness were higher in reduced-fat frankfurters containing *makgeolli* lees fiber than in the control with 30% fat. With increasing fat levels, samples displayed higher pH, lightness, hardness, cohesiveness, gumminess, chewiness, apparent viscosity, and sensory quality, while displaying lower cooking loss and total expressible fluid. The results show that fat levels of frankfurters with added *makgeolli* lees fiber can be successfully reduced. Thus, 20% fat frankfurters with the addition of 2% *makgeolli* lees fiber are similar in quality to regular frankfurters with 30% fat.

1. Introduction

It is recommended that consumers reduced their intake of animal fat (Choi, Choi, Han, Kim, Lee, Kim et al., 2010). Animal fat intake is related with obesity, hypertension, cardiovascular disease, and coronary heart disease (Choi, Choi, Han, Kim, Lee, Jeong et al., 2010; Choi et al., 2009; Luruena-Martinez, Vivar-Quintana, & Revilla, 2004; Ozvural & Vural, 2008). Traditional meat products such as frankfurters and patties may contain up to 30% fat (Choi et al., 2009; Woo, Lee, & Kim, 1995). Therefore, reduced-fat and low-fat meat products are of interest. However, fat is important as a source of energy and essential fatty acids, and as carriers of fat soluble vitamins (Choi et al., 2009; Vural, Javidipour, & Ozbas, 2004). Also, fat plays important roles in stabilization of meat emulsions, reducing cooking loss, and improving flavor, texture, tenderness, juiciness and mouth feel (Choi, Choi, Han, Kim, Lee, Kim et al., 2010; Muguerza, Fista, Ansorena, Astiasaran, & Bloukas, 2002). Furthermore, fat influences the binding, rheological, and structural properties of meat products (Hughes, Cofrades, & Troy, 1997). While the number of reduced-fat meat products has increased, consumer acceptance of these products has been slow.

Overcoming consumer reluctance has involved partial substitution of animal fat by water and dietary fiber such as rice bran fiber, wheat fiber, carrageenan, pectin, cellulose gums, and citrus fiber (Barbut & Mittal, 1996; Candogan & Kolsarici, 2003; Cengiz & Gokoglu, 2007; Choi, Choi, Han, Kim, Lee, Kim et al., 2010). Adding dietary fiber to meat products helps improve the textural properties and emulsion stability of meat products (Aleson-Carbonell, Fernandez-Lopez, Sayas-Barbera, Sendra, & Perez-Alvarez, 2003; Bloukas & Paneras, 1993; Choi et al., 2008). Dietary fiber is desirable not only functionally and technologically, but also for its nutritional value (Choi, Park, Choi, Kim, Song, Kim et al., 2010).

Considerable quantities of *makgeolli* lees result from the *makgeolli* brewed using *nuruk* or *koji* (Kim & Cho, 2006; Lee, Lee, Noh, & Park, 1996). *Makgeolli* lees is the most important by-product, and provides dietary fiber, energy, proteins, minerals, vitamins, alcohol, and organic acids (Lee et al., 2009). Thus, *makgeolli* lees is an outstanding source of dietary fiber with high nutritive value (Choi, Park, Choi, Kim, Song, Kim et al., 2010). *Makgeolli* is a traditional Korean rice wine that is one of the country's most popular alcoholic drinks (Bae, Jung, Kim, Shin, & Suh, 2010; Choi, Park, Choi, Kim, Song, Kim et al., 2010). The by-products of *makgeolli* processing are normally used as animal feed or fertilizers, and are a major contributor to environmental contamination due to waste *makgeolli* lees (Lee, Hong, Yoon, Kim, & Kim, 2009). The utilization of *makgeolli* lees in commercial products is limited. A study

* Corresponding author. Tel.: +82 2 450 3684; fax: +82 2 444 6695.
E-mail address: kimcj@konkuk.ac.kr (C.-J. Kim).

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on the use of dietary fiber extracted from *makgeolli* lees in chicken meat emulsion systems reported excellent meat product quality with the addition of 1–2% fiber extracted from *makgeolli* lees (Choi, Park, Choi, Kim, Song, Kim et al., 2010).

The objective of this study was to evaluate the effects of various reduced-fat levels (10%, 15%, 20%, and 30%) and the addition of 1% and 2% *makgeolli* lees fiber on the approximate composition, energy value, pH, color, cooking loss, emulsion stability, texture profile analysis, apparent viscosity, and sensory quality of reduced-fat frankfurters.

2. 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). *Makgeolli* lees obtained from Seoul TAKJU Map Association, Seoul, Korea was freed from alcoholic components by washing three times with four volumes of water (25 °C), and the residue was dried (55 °C) overnight in an air oven and cooled. The *makgeolli* lees was gelatinized with 0.6% Termamyl (heat stable alpha-amylase) at 95 °C for 1 h to remove starch, followed by filtration. The residue was then washed three times with four volumes of heated water (100 °C) and allowed to equilibrate to room temperature (20 °C, 6 h). The residue was then washed with 99.9% ethanol (preheated to 60 °C), followed by filtration. The residue was dried (55 °C) overnight in an air oven and then cooled. The *makgeolli* lees fiber (moisture 3.42%, fat 5.98%, protein 15.51%, ash 0.60%, dietary fiber 60.39%; L^*-value: 67.35, a^*-value: 4.62, b^*-value 16.09, pH 4.76) was then placed in polyethylene bags, vacuum packaged (FJ-500XL, Fujee Tech, Seoul, Korea) and stored at 4 °C until used for product manufacture (Choi, Park, Choi, Kim, Song, Kim et al., 2010).

2.2. Frankfurter preparation and processing

Fresh chicken breast meat (broiler, *Musculus pectoralis major*, 5 weeks of age, approximately 1.5–2.0 kg live weight, moisture 74.95%, protein 22.58%, fat 1.09%, ash 1.31%) and pork back fat (moisture 12.73%, fat 85.73%) were purchased from a local processor. The chicken breast meat and pork fat were initially ground through an 8 mm diameter plate. The ground tissue was then placed in polyethylene bags, vacuum sealed as described above, and stored at 0 °C until required for product manufacture, within 6 h. Ten different batters were produced; the experimental design and compositions are given in Table 1. Each batch of samples consisted of 10 meat batters, which differed in composition with respect to fat level (10%, 15%, 20%, and 30%) and the addition of dietary fiber extracted from *makgeolli* lees fiber (0%, 1%, and 2%). This was performed in triplicate for each batter (using meat batters of 10 kg). All analyses were carried out in triplicate for each formulation. The first meat batter served as the control and was prepared with 30% pork back fat without *makgeolli* lees fiber. The optimum *makgeolli* lees fiber levels (1% and 2%) were determined as previously described (Choi, Park, Choi, Kim, Song, Kim et al., 2010). Target fat levels were 10%, 15%, 20%, and 30%; the protein levels were kept constant with water replacing fat in reduced-fat frankfurters. Four products were prepared containing 10%, 15%, 20%, and 30% fat. *Makgeolli* lees fiber was added separately to each formulation at 0%, 1%, and 2%. The meat was homogenized, ground for 1 min in a silent cutter (Nr-963009, Hermann Scharfen GmbH & Co, Postfach, Germany), then chilled in iced water (2 °C). Sodium chloride (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 (0%, 1%, and 2%) and pork back fat were added after 3 min. The meat batters were homogenized for 5 min. A temperature probe (Model KM330, Kane-May, Harlow, UK) was used to monitor the temperature of the emulsion, which was maintained below 10 °C throughout the preparation. After emulsification, the meat batter was stuffed into collagen casings (Model #240, NIPPI, Tokyo, Japan; approximate diameter, 2.5 cm) using a stuffer (Model IS-8, Sirman, Marsango, Italy). The meat batters were then heated to 75 ± 2 °C for 30 min in a water bath (Model 10-101, Dae Han Co., Seoul, Korea) and then cooled in water (21 °C). The frankfurters were placed in polyethylene bags, vacuum packaged and maintained below 10 °C during preparation.

2.3. Proximate composition

Compositional analysis was performed using AOAC (2000). Moisture content (950.46B) was determined by weight loss after 12 h at 105 °C in a drying oven (SW-90D, Sang Woo Scientific Co., Bucheon, Korea). Fat content (960.69) was determined by the Soxhlet method with a solvent extraction system (Soxtec® Avanti 2050 Auto System, Foss Tecator AB, Höganas, Sweden) and protein content (981.10) was determined with an automatic Kjeldahl nitrogen analyzer (Kjeltec® 2300Analyzer Unit, Foss Tecator AB, Höganas, Sweden). Ash was determined according to AOAC method 920.153 (muffle furnace).

Table 1
Frankfurters formulations with varying percentages of added fat and *makgeolli* lees fiber (units: g/100 g).

Ingredients	Treatments[A]									
	30/0	20/0	20/1	20/2	15/0	15/1	15/2	10/0	10/1	10/2
Chicken breast meat	50	50	50	50	50	50	50	50	50	50
Back fat	30	20	20	20	15	15	15	10	10	10
Ice	20	30	29	28	35	34	33	40	39	38
Makgeolli lees fiber	–	–	1	2	–	1	2	–	1	2
Total	100	100	100	100	100	100	100	100	100	100
Sodium chloride (NaCl)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Sodium tripolyphosphate	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Sodium nitrite	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sugar	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

[A]The first number refers to the fat levels (30%, 20%, 15%, and 10%) and the second number to the added *makgeolli* lees fiber level (0%, 1%, and 2%).
30/0: Control with 30% pork back fat and without *makgeolli* lees fiber.
20/0: Treatment with 20% pork back fat and without *makgeolli* lees fiber.
20/1: Treatment with 20% pork back fat and with 1% *makgeolli* lees fiber.
20/2: Treatment with 20% pork back fat and with 2% *makgeolli* lees fiber.
15/0: Treatment with 15% pork back fat and without *makgeolli* lees fiber.
15/1: Treatment with 15% pork back fat and with 1% *makgeolli* lees fiber.
15/2: Treatment with 15% pork back fat and with 2% *makgeolli* lees fiber.
10/0: Treatment with 10% pork back fat and without *makgeolli* lees fiber.
10/1: Treatment with 10% pork back fat and with 1% *makgeolli* lees fiber.
10/2: Treatment with 10% pork back fat and with 2% *makgeolli* lees fiber.