PE4.50 Optimization of replacing pork back fat with grape seed oil and rice bran fiber for low-fat meat emulsion systems 176.00

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***Abstract*—The effects of reducing pork fat levels from 30% to 20% and partially substituting the pork fat with a mix of grape seed oil (0%, 5%, 10% and 15%) and 2% rice bran fiber were investigated on chemical composition, cooking characteristics, physicochemical and textural properties, and viscosity of low-fat meat batters. For low-fat meat batters samples which contain grape seed oil and rice bran fiber the moisture, ash content, uncooked and cooked pH, b^*-value, cohesiveness, gumminess, chewiness, and sarcoplasmic protein solubility were found to be higher than the control samples. Results showed that increasing grape seed oil concentrations among the treatments with grape seed oil and rice bran fiber, will lower the cooking loss, emulsion stability, and apparent viscosity. The results of this study show that the incorporation of grape seed oil and rice bran fiber in the formulation will successfully reduce animal fat in the final meat products while improving other characteristics important to consumers.**

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***Index Terms* — Rice bran fiber, Grape seed oil, Low-fat, Meat emulsion, Pork back fat.**

I. INTRODUCTION

GENERALLY, traditional meat products contain up to 30% fat. The fat plays an important technological role during meat product processing, which is to stabilize meat emulsions, reduce cooking loss, improved water holding capacity, provided flavor, textural, juiciness and desired mouth feel. However, high fat content such as animal fat provides high amounts of saturated fatty acids and cholesterol in meat products [1]. High animal fat intake is associated with obesity, hypertension, cardiovascular diseases and coronary heart diseases due to saturated fatty acids and cholesterol [2]. Therefore, the reduction of fat content in meat products and the substitution of animal fat with vegetable oils should result in a healthier product.

The grapes (*Vitis vinifera L.*) are the world's largest fruit crop. Among by-products, grape seed is considered to be valuable for oil extraction [3]. Therefore, grape seed oils are free of cholesterol and have a higher ratio of unsaturated to saturated fatty acids than animal fats. Also, grape seed oil is high quality culinary oil having a high smoke point of 252 ˚C, which makes it a good choice for frying and other high temperature food applications [4]. Because grape seed oil spreads and mixes better with food, requires 50% less quantity due to its stability and fluidity properties [5]. Some studies have shown that the use of certain vegetable oils in meat products could improve their nutritional quality by reducing caloric and cholesterol contents without adversely affecting the palatability of the product [6]. Moreover, dietary fiber has been added to various meat products to hinder the problems caused by fat reduction. Many researchers reported that low-fat meat products with fat partially replaced by dietary fiber help improve rheological properties and stability [7]. Rice bran is a dietary fiber source, which consists of dietary fiber, proteins, minerals and vitamin B components, [8].

Therefore, the objective of this study was to investigate the effect of replacing animal fat with various levels of grape seed oils, emulsified with dietary fiber extracted from rice bran of low-fat meat batter.

II. MATERIALS AND METHODS

A. Preparation and processing of rice bran fiber extract

The dietary fiber was extracted using the modified AOAC enzymatic-gravimetric method (AOAC, 1995). The rice bran coming from a Japonica rice cultivar (*Oriza sativa* L.) was purchased from a market in Geochang, Gyeongsangnam-do, Korea, ground in a mill, passed through a 25 mesh sieve roasted at 105˚C and defatted with hexane (n-hexane 95%) on a shaker (BS-11, Lab. Companion, Seoul, Korea) overnight. The defatted rice bran 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 washed three times with four volumes of boiling water (100˚C), allowed to equilibrate at room temperature (20˚C, 6 h) then washed with 99.9% ethanol (preheated to 60˚C), followed by filtration. The resulting residue was dried (55˚C) overnight using an air oven and cooled. The dietary fiber extracted from rice bran was placed in polyethylene bags, vacuums sealed, using a vacuum packaging system (FJ-500XL, Fujee Tech., Seoul, Korea), and stored at 4˚C until used for product manufacturing.

B. Meat batter preparation and processing

Fresh pork ham (*M. biceps femoris, M. semitendinosus, M. semimembranosus*) and pork back fat (moisture 12.61%, fat 85.64%) were purchased from a local processor 48 h postmortem. All subcutaneous, intramuscular fat and visible connective tissue were removed from muscle. Lean materials were initially ground through an 8 mm plate and the pork back fat was also ground through the 8 mm plate. The ground tissue was then placed in polyethylene bags, vacuum sealed using a vacuum packaging system (FJ-500XL, Fujee Tech, Seoul, Korea) and stored at 0˚C until required for product manufacturing. Suitable amounts of muscle and fat were stored at 4˚C for 24 h prior to meat batter preparation. Grape seed oil used to replace pork fat, was obtained from a local market and pre-emulsified on the day of use with eight parts hot water and mixed for 2 min with one part isolated soy protein. The mixture was emulsified with 10 parts grape seed oil for 3 min (Paneras & Bolukas, 1994). Six different meat batters were produced and the experimental design and compositions are given in Table 2. The first meat batter is the control and was prepared with 30% pork back fat. The second meat batter (T1) was prepared with 20% pork back fat. Meat batter T2 was prepared with 20% pork back fat and 2% rice bran fiber added. The next three meat batters were prepared with pre-emulsified grape seed oil. The following combination of grape seed oil, back fat and rice bran were used; T3: pork back fat 15% + grape seed oil 5% + rice bran fiber 2%; T4: pork back fat 10% + grape seed oil 10% + rice bran fiber 2%; T5: pork back fat 5% + grape seed oil 15% + rice bran fiber 2%. Pork meat was homogenized, ground for 1 min in a silent cutter (Cutter Nr-963009, Hermann Scharfen GmbH & Co, Postfach, Germany) then chilled in iced water (2 ˚C). 1.5% NaCl, 0.2% sodium tripolyphosphate, 0.01% sodium nitrite, and 0.5% sugar, were added to the meat and mixed for 1 min. 2% rice bran fiber was used for the samples and pork back fat or pre-emulsified vegetable oil was added after 3 min. The meat batters were homogenized for 6 min.

C. pH

The pH values of meat batters were measured in a homogenate prepared with 5 g of sample and distilled water (20 ml) using a pH meter (Model 340, Mettler-Toledo GmbH, Schwerzenbach, Switzerland).

D. Proximate composition

Compositional properties of the meat batters were performed using AOAC (1995).

E. Cooking loss

Cooking loss was determined by calculating the weight differences before and after cooking.

F. Emulsion stability

The meat batters were analyzed for emulsion stability using the method of Blouka and Honikel [9] with the following modifications.

G. Color evaluation

The color of each meat batter was determined using a colorimeter (Minolta Chroma meter CR-210, Minolta Ltd., Osaka, Japan; illuminate C, calibrated with a white plate, L^*=+97.83, a^*=-0.43, b^*=+1.98). Lightness (L^*- value), redness (a^*- value), and yellowness (b^*-value) values were recorded.

H. Apparent viscosity

Meat batter viscosity was measured in triplicate with a rotational viscometer (HAKKE Viscotester® 550, Thermo Electron Corporation, Karlsruhe, Germany) set at 10 rpm.

I. Texture profile analysis

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

J. Statistical analysis

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

III. RESULTS AND DISCUSSION

The difference in moisture, fat, and ash contents of the various meat batters are shown to be statistically significant (P<0.05), except for protein content which shows no statistical significant difference. The moisture content of the meat batter samples with grape seed oil and rice bran fiber were higher than the control sample because the control sample has 20% less water added. The protein content showed no significant difference between control sample and the treatments with low-fat meat batter formulated with grap seed oil and rice bran fiber. The fat content was significantly lower in the batters formulated with grape seed oil and rice bran fibercompared to control sample. The fat levels for the meat batters (fat replaced with grape seed oil, water, and rice bran fiber) are close to the target value of 20%.

Cooking loss for treatment T1 has the highest value (about 29%), and the control sample loss was higher only than the low-fat meat batters T4 and T5 treatments. The meat batter treatment T1 had the highest total expressible fluid, thus decreasing the stability of the emulsion. Increasing the grape seed oil level from 0% to 15% significantly decreased the total expressible fluid and no significant difference in expressible fluid was observed between the treatments with 5% to 15% concentration of grape seed oil. The fat loss of the T1 low-fat meat batter sample was the highest but comparing the control samples with the other treatments, with the execption of T1, no changes in grape seed oil levels and rice bran fiber were observed. The control and all tested low-fat batters samples were found to have thixotropic behavior with apparent viscosity values that decreased with an increase in rotation time. The significant changes in viscosity that were observed for the reduced fat meat batters were due to the higher fat concentration found in control sample compared to the samples with graep seed oil added. The low-fat meat batters with increasing concentration of grape seed oil resulted in higher sarcoplasmic protein solubility compared to control sample. Among the treatments with grape seed oil and rice bran fiber, as we increased the grape seed oil concentrations we observed higher myofibrillar protein and total protein solbility with each increase and this solubilities were also higher than, T1 and T2 samples. Different grape seed oil concentrations and rice bran fiber replacement affected the textural properties of low-fat meat batters. Low-fat meat batters without grape seed oil and rice bran fiber (T1) had the lowest values for hardness and as we increased the grape seed oil concentrations we observed significantly increased hardness. Gumminess and chewiness of T1 had the lowest value, and by increasing the grape seed oil concentrations we increased the gumminess and chewiness of low-fat meat batters.

Table 1. Proximate composition of uncooked meat batters formulation with varying grape seed oil levels and rice bran fiber

Treatments[1)]	Moisture (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	Ash (g/100 g)
Control	58.51±1.02^{c}	10.90±0.50	29.96±0.99^{a}	1.80±0.10^{b}
T1	65.98±1.03^{ab}	10.25±0.67	21.01±0.91^{b}	1.83±0.07^{ab}
T2	64.11±0.69^{ab}	10.74±0.76	22.26±0.78^{b}	1.91±0.11^{a}
T3	66.07±0.98^{a}	10.63±0.66	22..41±0.63^{b}	1.93±0.08^{a}
T4	66.04±0.75^{a}	10.48±0.89	22.82±0.91^{b}	1.97±0.15^{a}
T5	63.31±1.36^{b}	10.85±0.75	21.15±0.65^{b}	1.94±0.10^{a}

All values are mean ± standard deviation of three replicates (n=10)

[a-d] Means within a column with different letters are significantly different (P < 0.05).

[1)] Control: pork back fat (30%), T1: pork back fat (20%), T2: pork back fat (20%) + rice bran fiber (2%), T3: pork back fat (15%) + grape seed oil (5%) + rice bran fiber (2%), T4: pork back fat (10%) + grape seed oil (10%) + rice bran fiber (2%), T5: pork back fat (5%) + grape seed oil (15%) + rice bran fiber (2%).

Table 2. Effects of cooking loss and emulsion stability of low-fat meat batters formulated with varying grape seed oil levels and rice bran fiber

Treatments[1)]	Cooking loss (g/100g)	Emulsion stability	
		Total expressible fluid (ml/100g)	fat loss (ml/100g)
Control	15.23±0.24^{cd}	10.23±0.27^{b}	1.71±0.05^{b}
T1	29.26±0.83^{a}	19.22±1.37^{a}	2.28±0.35^{a}
T2	20.04±0.37^{b}	10.08±1.18^{b}	1.75±0.04^{b}
T3	18.15±0.79^{bc}	8.96±0.86^{c}	1.71±0.04^{b}
T4	13.67±0.70^{d}	8.93±0.39^{c}	1.69±0.06^{b}
T5	13.36±0.53^{d}	8.92±0.67^{c}	1.68±0.05^{b}

All values are mean ± standard deviation of three replicates (n=15)

[a-d] Means within a column with different letters are significantly different (P < 0.05).

[1)] Control: pork back fat (30%), T1: pork back fat (20%), T2: pork back fat (20%) + rice bran fiber (2%), T3: pork back fat (15%) + grape seed oil (5%) + rice bran fiber (2%), T4: pork back fat (10%) + grape seed oil (10%) + rice bran fiber (2%), T5: pork back fat (5%) + grape seed oil (15%) + rice bran fiber (2%)

Table 3. Effects of the textural attributes of meat batters formulated with varying grape seed oil levels and rice bran fiber

Treatments[1)]	Hardness (N)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (N)
Control	3.47±0.19^{ab}	0.95±0.03^{a}	0.51±0.02^{c}	1.76±0.12^{bc}	1.66±0.11^{b}
T1	3.03±0.15^{d}	0.90±0.02^{c}	0.55±0.04^{b}	1.68±0.15^{c}	1.51±0.11^{c}
T2	3.24±0.20^{c}	0.93±0.02^{ab}	0.57±0.04^{ab}	1.84±0.17^{b}	1.71±0.15^{b}
T3	3.32±0.32^{bc}	0.92±0.03^{b}	0.56±0.03^{ab}	1.87±0.20^{b}	1.73±0.21^{b}
T4	3.51±0.14^{a}	0.93±0.02^{ab}	0.58±0.04^{ab}	2.04±0.17^{a}	1.89±0.16^{a}
T5	3.53±0.17^{a}	0.93±0.01^{ab}	0.59±0.02^{a}	2.09±0.12^{a}	1.94±0.12^{a}

All values are mean ± standard deviation of three replicates (n=15)
$^{a\text{-}c}$ Means within a column with different letters are significantly different (P < 0.05).
[1)] Control: pork back fat (30%), T1: pork back fat (20%), T2: pork back fat (20%) + rice bran fiber (2%), T3: pork back fat (15%) + grape seed oil (5%) + rice bran fiber (2%), T4: pork back fat (10%) + grape seed oil (10%) + rice bran fiber (2%), T5: pork back fat (5%) + grape seed oil (15%) + rice bran fiber (2%).

IV. CONCLUSION

In this experiment we showed that reducing total fat levels from 30% to 20%, and addition of grape seed oil and rice bran fiber has an important effect on the quality of low-fat meat batters. The results of this study showed that replacing up to 50% pork back fat with pre-emulsified grape seed oil in low-fat meat batter formulations is the best optimization of quality characteristics. The incorporation of grape seed oil and rice bran fiber in the formulation successfully reduced animal fat in the final meat products.

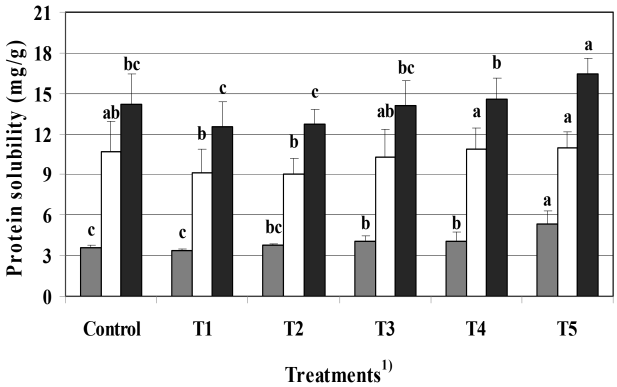

Fig. 1. Effect of protein solubility on uncooked meat batter containing various grape seed oil levels and rice bran fiber

$^{a\text{-}c}$ Means within a sharing with different letters are significantly different (P < 0.05).
[1)] Control: pork back fat (30%), T1: pork back fat (20%), T2: pork back fat (20%) + rice bran fiber (2%), T3: pork back fat (15%) + grape seed oil (5%) + rice bran fiber (2%), T4: pork back fat (10%) + grape seed oil (10%) + rice bran fiber (2%), T5: pork back fat (5%) + grape seed oil (15%) + rice bran fiber (2%), ■: sarcoplasmic protein, □ : myofibrillar protein, ■: total protein.

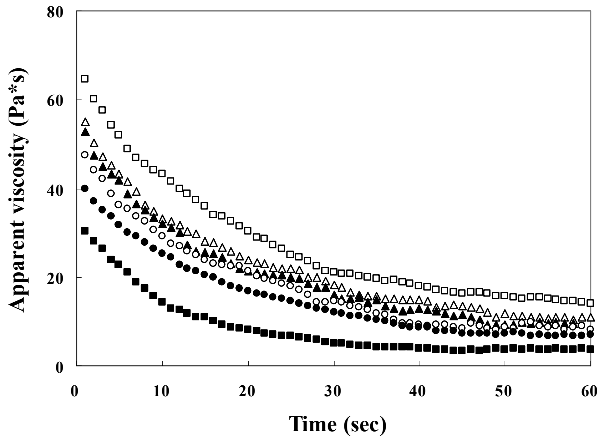

Fig. 2. Change of apparent viscosity on low-fat meat batter containing various grape seed oil levels and rice bran fiber stirred for 1 min.

(□) Control: pork back fat (30%), (■) T1: pork back fat (20%), (△) T2: pork back fat (20%) + rice bran fiber (2%), (▲) T3: pork back fat (15%) + grape seed oil (5%) + rice bran fiber (2%), (○) T4: pork back fat (10%) + grape seed oil (10%) + rice bran fiber (2%), (●) T5: pork back fat (5%) + grape seed oil (15%) + rice bran fiber (2%).

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