

Quality and Sensory Characteristics of Reduced-fat Chicken Patties with Pork Back Fat Replaced by Dietary Fiber from Wheat Sprout

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Abstract

The effects of reducing pork fat levels from 20% to 15% or 10% by partially substituting pork back fat with wheat sprout fiber in reduced-fat chicken patties were investigated. Approximate composition, energy value, pH, color, cooking loss, reduction in diameter, reduction in thickness, shear force, and sensory properties were determined. Moisture content, ash contents, yellowness of uncooked and cooked reduced-fat chicken patties with wheat sprout were higher than those in the control, while displaying fat content, calorie content, and pH of uncooked and cooked lower in reduced-fat chicken patties than in the control. Cooking loss, reduction in diameter, and reduction in thickness were the highest in the reduced-fat chicken patties with 10% fat level. Cooking loss, reduction in diameter, and reduction in thickness were decreased when fat levels and wheat sprout levels were increased. Control samples without wheat sprout dietary fiber had significantly ($p < 0.05$) higher color and flavor scores compared to reduced-fat chicken patties containing wheat sprout dietary fiber. The overall acceptability of the control and treatment with 15% fat and 2% wheat sprout dietary fiber (T3) was the highest. Therefore, 15% fat level in reduced-fat chicken patties with the addition of 2% wheat sprout dietary fiber can be used to improve the quality and sensory characteristics of regular-fat chicken patties containing 20% fat level.

Keywords: reduced-fat, dietary fiber, chicken patties, wheat sprout, sensory properties

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Introduction

Intake of animal fat containing high levels of saturated fatty acid and cholesterol is associated with obesity, hypertension, cardiovascular disease, and coronary heart disease (Choi *et al.*, 2014; Zhuang *et al.*, 2016). It has been recommended that consumers should reduce their intake of animal fat because reduced-fat meat product is better for health (Choi *et al.*, 2015). However, fat is an important source of energy and essential fatty acids. In addition, it is carrier of fat soluble vitamins (Choi *et al.*, 2009; Vural *et al.*, 2004). In addition, animal fat in meat products plays important roles in providing flavor, texture, juiciness, and desired mouth feel (Choi *et al.*, 2012). Furthermore, ani-

mal fat can affect the binding, rheological, and structural properties of meat products (Hughes *et al.*, 1997). Thus, it is important to reduce animal fat in meat products to the minimum to keep these beneficial effects.

Wheat (*Triticum aestivum* L.), a member of the Poaceae (*Gramineae*) family, is consumed all around the world (An, 2015). Wheat has been used both as food and traditional medicine. It contains flavonol glycoside compounds that can be used to prevent edema and haemorrhagic diseases and stabilize high blood pressure (Chung and An, 2015). Wheat sprout contains high amounts of nutrients such as dietary fiber, minerals (iron, zinc, selenium), and vitamin required for human health (Pongrac *et al.*, 2016). Thus, wheat sprout is an excellent source of dietary fiber with high nutritive value (Chung and An, 2015). However, current utilization of wheat sprout in commercial products is limited.

In general, dietary fiber extracted from cereals, fruits, and vegetables had different structures and chemical compositions (Choi *et al.*, 2008). Dietary fiber can lower the risk of cancer formation and coronary heart diseases (Choi *et al.*, 2009). It can be used to reduce blood cholesterol

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level and prevent obesity (Lee *et al.*, 2008). To overcome consumer's reluctance, partial substitution of animal fat by dietary fiber has been practiced in reduced-fat meat processing (Choi *et al.*, 2007). Dietary fiber added to meat products can improve the water binding capacity and textural properties of meat products (Choi *et al.*, 2015). According to Choi *et al.* (2013), dietary fiber is desirable not only functionally and technologically, but also for its nutritional values.

The objective of this study was to evaluate the effects of various reduced-fat levels (10%, 15%, and 20%) and the addition of 1% or 2% wheat sprout to reduced-fat chicken patties on their approximate composition, energy value, pH, color, cooking loss, reductions in thickness and diameter, shear force, and sensory evaluation.

Materials and Methods

Preparation of wheat sprout

Wheat (*Triticum aestivum* L.) sprouts were obtained from local market, Seongnam, Korea. Raw buckwheat sprouts were washed three times with four volumes of water (25 °C). The cleaned buckwheat sprouts were freeze dried. The dried buckwheat sprouts were pulverized to milling systems and passed through a 35-mesh sieve (particle size of <0.5 mm). The crushed buckwheat sprouts (moisture content: 2.48%; fat content: 5.47%; protein content: 30.36%; ash content: 0.95%; dietary fiber: 39.87%; L*-value: 59.46; a*-value: -6.12; b*-value: 23.43; pH: 5.82) were then placed in polyethylene bags, packaged using a vacuum packaging system (FJ-500XL, Fujee Tech., Korea), and stored at 4°C until used for product manufacture.

Chicken patties preparation and processing

Fresh chicken breast (*M. pectoralis major*) and pork back fat (moisture 12.78%, fat 85.42%) were purchased from a local processor. These chicken breast and pork fat were ground through an 8-mm plate, and then ground through a 3-mm plate. Each batch of samples consisted of seven chicken patties with different fat levels (10%, 15%, and 20%) and buckwheat sprout powder (0%, 1%, and 2%). Chicken patties were produced using the traditional recipe (Choi *et al.*, 2012). The mix of chicken patty was kneaded for 15 min at 4°C by hand. The chicken patty mixtures were divided into seven equal portions (Table 1). Each portion was kneaded for an additional 15 min to obtain homogeneous mixtures. These mixtures shaped with a household hamburger mold (PM 10/13 Burger press, AB Services Food Machinery, England; diameter:

10.0 cm, thickness: 2.3 cm) into meat products with a weight of about 90 g. Chicken patties were cooked on a preheated grill (CG20, USA) at grill surface temperature of 150°C. They were cooked for 3 min on one side and 3 min on the opposite side until the targeted core temperature reached 75°C. The core temperature of the pork patties was monitored with a digital thermometer (Tes-1305, Tes Electrical Co., Taiwan) equipped with a data logger (RS-232, Tes Electrical Co., Taiwan) by inserting an iron constant an thermocouple.

Proximate composition

The moisture content (950.46B, Oven drying method), fat content (960.69, Soxhlet method), protein content (981.10, Kjeldahl method), and ash content (920.153, Muffle furnace method) of the chicken patties were determined using an AOAC (2000).

Caloric content

The caloric contents were obtained by the Mansour and Khalil (1999) method. Total calorie estimates (kcal) for chicken patties were calculated on the basis of a 100 g portion using At water values.

pH

The pH values of raw and cooked chicken patties were measured in a homogenate (Ultra-Turrax T25, Janke & Kunkel, Germany) prepared with 5 g of sample and distilled water (20 mL) using a pH meter (Model 340, Mettler-Toledo GmbH, Switzerland).

Color evaluation

The color of each raw and cooked chicken patty was determined using a colorimeter (Minolta Chroma meter CR-210, Minolta Co., Japan; illuminate C, calibrated with a white plate, L* = +97.83, a* = -0.43, b* = +1.98). The lightness (CIE L*-value), redness (a*-value), and yellowness (b*-value) values were recorded.

Cooking loss

Cooking loss was determined by calculating the weight differences before and after cooking as follows:

$$\text{Cooking loss (\%)} = \left[\frac{\text{weight of raw chicken patty (g)} - \text{weight of cooked chicken patty (g)}}{\text{weight of raw chicken patty (g)}} \right] \times 100$$

Reductions in diameter and thickness

The diameter and thickness of the raw and cooked pat-

ties were recorded using vernier calipers (530-122, Mitutoyo, Japan) and calculated using the following expression.

$$\text{Reduction in diameter (\%)} = [(\text{raw chicken patty diameter} - \text{cooked chicken patty diameter}) / \text{raw chicken patty diameter}] \times 100$$
$$\text{Reduction in thickness (\%)} = [(\text{raw chicken patty thickness} - \text{cooked chicken patty thickness}) / \text{raw chicken patty thickness}] \times 100$$

Shear force

Shear force was performed at room temperature with a texture analyzer (TA-XT2i, Stable Micro Systems Ltd., England). Chicken patty samples were taken from the central portion of each meat patty. Prior to analysis, samples were allowed to equilibrate to room temperature (20°C, 3 h). Each patty was cut with a knife into 5.0 cm (L) × 2.5 cm (W) × 2.0 cm (D) and the sections were sheared in two separate locations with a Warner-Bratzler blade set attached to a texture analyzer. Test speed was set at 2 mm/s. Data were collected and analyzed to determine shear force values and the maximum force required to shear through each sample (Bourne, 1978).

Sensory evaluation

The sensory evaluations were performed in triplicate on each sample by sensory panelist. Training of panelists was performed according to sensory evaluation procedure (Lawless & Heymann, 1999). Each chicken patty was evaluated in terms of color, flavor, juiciness, tenderness, and overall acceptability. Chicken patties were cut into quarters (size: 5.0 × 5.0 × 2.0 cm), and served to the panelists randomly. The color (1 = extremely undesirable, 10 = extremely desirable), flavor (1 = extremely undesirable, 10 = extremely desirable), tenderness (1 = extremely tough, 10 = extremely tender), juiciness (1 = extremely dry, 10 = extremely juicy), and overall acceptability (1 = extremely undesirable, 10 = extremely desirable) of the cooked samples were evaluated using a 10-point descriptive scale. This analysis was conducted using the hedonic test described.

Statistical analysis

All tests were done at least three times for each experimental condition and mean values are reported. An analysis of variance was performed on all the variables using the general linear model (GLM) procedure of the SAS (Statistical Analysis Systems Institute, 2011) statistical package. Duncan's multiple range test ($p < 0.05$) was used to

determine the differences between treatment means.

Results and Discussion

Proximate composition and caloric content

Proximate compositions of reduced-fat chicken patties formulated with different amounts of fat and wheat sprout are shown in Table 2. The moisture content of reduced-fat chicken patties was higher than that of control patties with regular-fat level. Moisture content was increased significantly when fat level was reduced from 20% to 10% because reduced fat samples had less fat and more water. Protein content of chicken patties ranged from 16.48% to 18.58%. The protein content was slightly decreased when wheat sprout level was increased from 0% to 2%. Fat contents in chicken patties formulated with reduced-fat and wheat sprout were significantly ($p < 0.05$) lower than those of control patties. Ash contents of reduced-fat chicken patties samples containing wheat sprout were higher than those of the control patties. Ash content was significantly ($p < 0.05$) increased when wheat sprout level was increased from 0% to 2%. Similar trends in proximate composition have been reported in studies of Choi *et al.* (2012) when *Laminaria japonica* is added to reduced-fat pork patties. They have reported that reduced-fat pork patties containing *Laminaria japonica* have significantly higher moisture contents and ash contents than control patties while protein content and fat content of control samples with regular-fat level are higher than reduced-fat pork patties containing *Laminaria japonica*. Choi *et al.* (2014b) have reported that the proximate composition of reduced-fat frankfurters is supported by dietary fiber extracted from *makgeolli* lees. They have indicated that the moisture and ash contents in reduced-fat frankfurters containing *makgeolli* lees fiber are higher than those in control frankfurters with regular-fat level. They have closely approximated targeted fat concentration for the samples. An (2015) has reported that the moisture content of foods containing wheat sprout are higher than those in the control due to the fact that wheat sprout contains 37% dietary fiber. According to Choi *et al.* (2008), emulsion-type sausages with dietary fiber from rice bran have higher moisture and ash contents than control sausages without rice bran fiber. That is, depending on dietary fiber sources, the proximate composition of meat products can be different.

Energy values of reduced-fat chicken patties formulated with different fat levels and wheat sprout were significantly ($p < 0.05$) lower than those of controls. When wheat sprout concentration was increased from 0% to 2% with

Table 1. Reduced-fat chicken patties formulated with wheat sprout (units: %)

Ingredients	Treatments ¹⁾						
	Control	T1	T2	T3	T4	T5	T6
Chicken breast	60	60	60	60	60	60	60
Pork back fat	20	15	15	15	10	10	10
Ice	20	25	24	23	30	29	28
Wheat sprout			1	2		1	2
Total	100	100	100	100	100	100	100
Sodium chloride	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Sodium tripolyphosphate	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Isolated soy protein	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Sorbitol	1.0	1.0	1.0	1.0	1.0	1.0	1.0

¹⁾Control, 20% fat; T1, 15% fat; T2, 15% fat + 1% wheat sprout; T3, 15% fat + 2% wheat sprout; T4, 10% fat; T5, 10% fat + 1% wheat sprout; T6, 10% fat + 2% wheat sprout.

fat level reduced from 20% to 10%, the energy values of reduced-fat chicken patties were decreased significantly ($p < 0.05$). This was due to the fact that reduced-fat treatments had fat replaced by water and wheat sprout. Similar trends in energy values have been observed by Choi *et al.* (2012). It has been reported that meat patties with reduced-fat containing *Laminaria japonica* fiber have less energy values than control patties with regular fat level due to the fact that reduced-fat treatments samples have less fat but more water and dietary fiber sources (Choi *et al.*, 2012). Cengiz and Gokoglu (2005) have reported that frankfurters with reduced fat and fat replacer have lower energy values because energy values can be affected by fat replacer levels and water content. Some researchers have reported that energy values of meat products were depend on added fat levels because fat has 9.0 kcal of energy per / gram (Choi *et al.*, 2010; Salcedo-Sandoval *et al.*, 2012).

pH and color

The pH and color of reduced-fat chicken patties with various fat levels and 1% or 2% of wheat sprout are shown in Table 3. The pH values of uncooked and cooked chic-

ken patties samples were the highest in control. Increased wheat sprout levels were associated with decreased pH values of uncooked and cooked chicken patties in samples with the same fat level. Increasing fat level from 10% to 20% significantly increased the pH values of uncooked and cooked chicken patties, indicating that the pH values of meat products could be affected by fat levels and wheat sprout levels. These results may be due the addition of wheat sprout whose pH was 5.82. Our results are in agreement with An (2015) who has reported that the pH values of food formulated with wheat sprout powder are lower than those of the control. Chung and An (2015) have reported that increasing wheat sprout levels can significantly decrease pH value because the pH values of products are affected by the pH of wheat sprout powder. Similar results have been reported by Choi *et al.* (2015) that the pH values of frankfurters with increasing fat levels in samples are slightly increased.

The differences in CIE L*-values (lightness), CIE a*-values (redness), and CIE b*-values (yellowness) of uncooked and cooked low-fat chicken patties containing different levels of wheat sprout were significant (Table 3). In samples with the same fat level, increasing wheat sprout

Table 2. Effect of wheat sprout on proximate composition and calorie of reduced-fat chicken patties

Traits	Treatments ¹⁾						
	Control	T1	T2	T3	T4	T5	T6
Moisture content (%)	57.91±0.24 ^d	60.94±1.63 ^c	60.25±0.87 ^c	59.96±0.87 ^c	65.76±0.95 ^a	64.23±1.59 ^a	62.77±1.35 ^b
Protein content (%)	18.58±1.56 ^a	18.54±1.02 ^a	17.48±1.50 ^{ab}	17.30±1.67 ^{ab}	17.10±0.75 ^{ab}	16.81±0.38 ^b	16.52±1.02 ^b
Fat content (%)	19.98±1.56 ^a	15.63±0.35 ^b	14.85±1.11 ^c	14.03±1.03 ^c	11.50±0.35 ^d	11.20±0.41 ^d	10.82±0.48 ^c
Ash content (%)	1.20±0.02 ^d	1.26±0.07 ^c	1.87±0.09 ^b	2.10±0.09 ^{ab}	1.29±0.04 ^c	1.90±0.12 ^b	2.77±0.62 ^a
Calorie (kcal)	263.53±5.47 ^a	229.25±4.62 ^b	225.25±3.44 ^b	221.40±3.41 ^c	189.07±3.89 ^d	191.05±3.24 ^d	191.35±2.41 ^d

All values are mean ± standard deviation of three replicates (n=9).

^{a-d}Means within a column with different letters are significantly different ($p < 0.05$).

¹⁾Control, 20% fat; T1, 15% fat; T2, 15% fat + 1% wheat sprout; T3, 15% fat + 2% wheat sprout; T4, 10% fat; T5, 10% fat + 1% wheat sprout; T6, 10% fat + 2% wheat sprout.

Table 3. Effect of wheat sprout on pH and color of reduced-fat chicken patties

Traits	Treatments ¹⁾							
	Control	T1	T2	T3	T4	T5	T6	
Uncooked	pH	6.27±0.01 ^a	6.24±0.02 ^b	6.23±0.02 ^{bc}	6.21±0.01 ^c	6.18±0.02 ^d	6.16±0.02 ^d	6.13±0.02 ^c
	L*-value	74.48±1.25 ^a	73.19±1.63 ^{ab}	54.62±1.84 ^d	49.42±1.29 ^e	72.31±0.99 ^b	59.39±0.84 ^c	48.74±1.69 ^e
	a*-value	4.70±0.89 ^a	4.66±0.92 ^a	-3.84±0.53 ^c	-5.17±0.15 ^b	3.77±0.64 ^b	-4.14±0.23 ^e	-6.12±0.18 ^c
	b*-value	12.39±1.28 ^f	14.77±1.03 ^e	26.15±1.37 ^c	26.99±2.20 ^{bc}	16.71±1.58 ^d	29.16±0.76 ^a	28.43±0.76 ^{ab}
Cooked	pH	6.30±0.02 ^a	6.27±0.02 ^b	6.24±0.01 ^c	6.25±0.02 ^c	6.24±0.01 ^c	6.23±0.02 ^c	6.20±0.01 ^d
	L*-value	81.32±0.48 ^a	80.57±1.31 ^b	64.93±0.68 ^d	58.94±1.18 ^e	80.12±0.35 ^b	67.90±1.39 ^c	59.77±0.86 ^e
	a*-value	0.38±0.12 ^a	0.37±0.09 ^a	-5.98±0.18 ^c	-6.99±0.32 ^d	-0.29±0.11 ^b	-5.93±0.21 ^c	-8.22±0.31 ^c
	b*-value	9.35±0.31 ^d	9.53±0.45 ^d	20.11±0.42 ^c	21.56±1.10 ^b	9.62±0.43 ^d	19.60±0.24 ^c	23.43±0.53 ^a

All values are the mean ± standard deviation of three replicates.

^{a-e}Means within a row with different letters are significantly different ($p < 0.05$).

¹⁾Control, 20% fat; T1, 15% fat; T2, 15% fat + 1% wheat sprout; T3, 15% fat + 2% wheat sprout; T4, 10% fat; T5, 10% fat + 1% wheat sprout; T6, 10% fat + 2% wheat sprout.

levels were associated with decreased lightness and redness of uncooked and cooked low-fat chicken patties samples. This could be due to the effect of wheat sprout color. Decreasing fat level from 20% to 10% significantly ($p < 0.05$) decreased the lightness and redness values of uncooked and cooked chicken patties. The yellowness values of uncooked and cooked low-fat chicken patties samples were significantly ($p < 0.05$) increased when wheat sprout level was increased in samples with the same fat level. The yellowness value of uncooked chicken patties was increased when fat level was decreased. The yellowness values of cooked chicken patties were not significantly different from each other at different fat levels. According to Chung and An (2015), food with increasing wheat sprout levels have significantly decreased lightness and redness values but increased yellowness values. This might be due chlorophyll in wheat sprout. Similar results on color changes have been reported by Park (2015) on the quality characteristics of muffins with sprout concentrate added. Crehan *et al.* (2000) have indicated that reducing fat concentrations can lead to significant decrease in lightness and yellowness of meat products. These results are in agreement with those of Choi *et al.* (2015). They have found similar trends of color change for frankfurters with different fat levels (5%, 12%, and 30%) (Choi *et al.*, 2015). Hand *et al.* (1987) have also reported that the lightness values of high fat frankfurters are greater than those of low fat frankfurters.

Cooking loss, reduction in diameter, and reduction in thickness

Results of cooking loss, reduction in diameter, and reduction in thickness of reduced-fat chicken patties formulated with various fat and wheat sprout levels are shown

in Table 4. The cooking loss was the highest in reduced-fat chicken patties containing 10% fat. When fat levels and wheat sprout levels were increased, the cooking loss was decreased. These results are in agreement with Choi *et al.* (2015) who have reported similar trend of cooking loss for frankfurters containing different fat levels (5%, 12%, and 30%) and 2% rice bran fiber. Choi *et al.* (2012) have reported that the cooking loss of reduced-fat patties containing *L. japonica* powder is significantly lower than that of control patties with regular-fat level. They have also reported that a reduction in fat content can cause significant increase in cooking loss compared to low-fat control due to the fact that these samples initially have more water contents than the controls. This is most likely due to the fact that dietary fiber sources have high water holding capacity and binding capacity. Lee *et al.* (2008) have reported that low-fat meat products without containing dietary fiber have the highest cooking loss during heating. Some researchers have reported that the addition of dietary fiber sources can decrease cooking loss in meat products (Choi *et al.*, 2010; Hughes *et al.*, 1997; Kim *et al.*, 2013; Turhan *et al.*, 2005). This is because cooking loss occurs through releasing fat and moisture. Cooking loss is related to the binding ability among meat protein, fat, and moisture. The differences in reduction in diameter and thickness of low-fat chicken patties formulated with various fat levels and wheat sprout levels were significant (Table 4). The reduction in diameter and thickness was decreased when fat contents and wheat sprout levels were increased. The reduction in diameter and thickness of low-fat chicken patties exhibited results similar to cooking loss. These results are consistent with those of Choi *et al.* (2012) who have reported that the reduction in diameter and thickness of reduced-fat pork patties containing diet-

Table 4. Effect of wheat sprout on cooking loss, reduction in diameter, and reduction in thickness of reduced-fat chicken patties

Traits	Treatments ¹⁾						
	Control	T1	T2	T3	T4	T5	T6
Cooking loss	12.11±2.71 ^{cd}	14.11±0.80 ^b	10.69±1.18 ^d	8.86±0.97 ^e	15.91±0.63 ^a	13.40±0.77 ^c	12.84±0.86 ^c
Reduction in diameter	8.02±1.20 ^{bc}	8.85±1.31 ^b	6.92±0.48 ^d	6.09±1.29 ^e	9.39±1.92 ^a	7.97±1.38 ^c	7.97±1.12 ^c
Reduction in thickness	12.86±1.97 ^c	14.77±1.59 ^b	13.93±1.27 ^{bc}	8.09±1.42 ^d	15.09±1.80 ^a	14.27±1.91 ^b	12.99±0.97 ^c

All values are mean ± standard deviation of three replicates (n=9).

^{a-e}Means within a column with different letters are significantly different ($p<0.05$).

¹⁾Control, 20% fat; T1, 15% fat; T2, 15% fat + 1% wheat sprout; T3, 15% fat + 2% wheat sprout; T4, 10% fat; T5, 10% fat + 1% wheat sprout; T6, 10% fat + 2% wheat sprout.

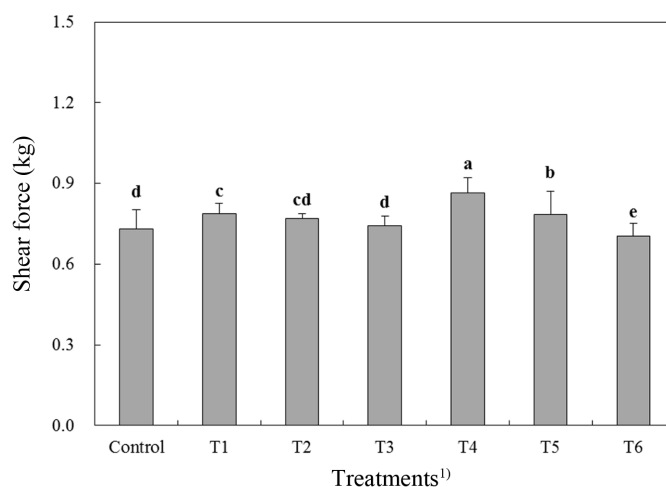


Fig. 1. Effect of wheat sprout on shear force of reduced-fat chicken patties. ¹⁾Control, 20% fat; T1, 15% fat; T2, 15% fat + 1% wheat sprout; T3, 15% fat + 2% wheat sprout; T4, 10% fat; T5, 10% fat + 1% wheat sprout; T6, 10% fat + 2% wheat sprout. a-e the different letters within shear force are significantly different ($p<0.05$).

ary fiber is significantly lower than that of control samples due to that fact that reduced-fat patties during cooking could improve the binding and stabilizing properties of dietary fiber. These results are also in agreement with the results of a study conducted by Turhan *et al.* (2005) on low-fat beef burgers made with various concentrations of hazelnut pellicle. Kim *et al.* (2013) have reported that pork patties containing brewer's spent grain dietary fiber have lower reduction in diameter and thickness because dietary fiber has high water holding capacity and binding capacity. Thus, improving water holding capacity and binding capacity of meat patties can decrease the reduction in diameter and thickness by reducing the deformation of patties during cooking.

Shear force

The shear forces of reduced-fat chicken patties formulated with various fat levels and wheat sprout levels are shown in Fig. 1. The shear forces of reduced-fat patties were decreased when fat levels were increased. The shear

forces of reduced-fat chicken patties with wheat sprout were decreased when wheat sprout levels were increased. Similar results have been reported by An (2015) who has demonstrated the effect of wheat sprout on foods. These results indicate that increasing wheat sprout level can decrease the hardness of cookies due to the water holding capacity of wheat sprout. Choi *et al.* (2011) have reported that chicken meat patties added with lotus leaf powder have lower values of hardness compared to control patties. An *et al.* (2010) has reported that the shear forces of meat products are gradually decreased in dietary fiber content. For these reasons, shear force needs to be changed in meat products because shear force is related to water holding capacity, moisture content, and cooking yield. However, Choi *et al.* (2014a) have reported that reduced-fat sausages with increasing pre-emulsion of brewer's spent grain levels have increased hardness. They have also reported that these improvements in textural properties might be due to dietary fiber because it has abilities of binding water and fat absorption. Previous studies have found that fat

Table 5. Effect of wheat sprout on sensory properties of reduced-fat chicken patties

Traits	Treatments ¹⁾						
	Control	T1	T2	T3	T4	T5	T6
Color	7.67±1.37 ^a	7.56±1.22 ^{ab}	6.89±0.98 ^c	6.75±1.33 ^c	7.52±1.22 ^{ab}	6.42±0.63 ^d	6.01±1.41 ^d
Flavor	7.83±1.17 ^a	7.52±1.38 ^{ab}	7.33±1.21 ^{ab}	6.83±0.41 ^b	7.07±0.63 ^b	7.01±0.41 ^{ab}	6.52±0.84 ^b
Tenderness	7.83±0.98	6.67±1.03	7.31±0.82	7.73±0.82	6.53±0.55	6.83±1.33	7.42±1.05
Juiciness	7.50±1.38	6.83±0.75	7.53±0.84	7.78±0.84	6.67±0.82	7.21±1.05	7.33±0.52
Overall acceptability	7.83±0.83 ^a	6.17±0.52 ^c	7.14±0.55 ^{ab}	7.67±0.82 ^a	6.08±0.74 ^c	6.52±0.75 ^b	6.83±0.98 ^b

All values are the mean ± standard deviation of three replicates (n=9).

^{a-d}Means within a row with different letters are significantly different ($p<0.05$).

¹⁾Control, 20% fat; T1, 15% fat; T2, 15% fat + 1% wheat sprout; T3, 15% fat + 2% wheat sprout; T4, 10% fat; T5, 10% fat + 1% wheat sprout; T6, 10% fat + 2% wheat sprout.

levels and dietary fiber can affect the textural properties of meat products (Kim *et al.*, 2013; Turhan *et al.*, 2005).

Sensory evaluation

The sensory scores of reduced-fat chicken patties with different fat and wheat sprout levels are summarized in Table 5. The color and flavor scores of control samples were significantly ($p<0.05$) higher than those of reduced-fat chicken patties containing wheat sprout. The tenderness and juiciness scores of samples were not significantly ($p>0.05$) different from those of the controls. The overall acceptability was the highest for the control patties and patties containing 15% fat and 2% wheat sprout (T3). Similar results have been obtained by Choi *et al.* (2012) on the sensory characteristics of reduced-fat pork patties. These results have revealed that the overall acceptability of reduced-fat pork patties containing 1% or 3% dietary fiber is the highest. According to Bloukas *et al.* (1993), dietary fiber has beneficial influence on the sensory quality of reduced-fat pork products. Choi *et al.* (2015) have reported that the overall acceptability scores of reduced-fat frankfurters with rice bran fiber are significantly higher than those without fiber added. There is no significant difference in acceptability among samples with various fat levels (Choi *et al.*, 2015). Chung and An (2015) have reported that sensory evaluation scores in terms overall preference of groups containing 3% and 6% of wheat sprout are not significantly different from each other or higher the control. Thus, reduced-fat and low-fat meat products may be produced through addition of dietary fibers to improve their sensory characteristics so that they are acceptable to consumers.

Conclusions

Reducing animal fat levels from 20% to 10% and adding 1% and 2% wheat sprout can improve the quality of

reduced-fat chicken patties. These results indicate that wheat sprout is a potentially excellent dietary fiber source that can be used as a functional ingredient for reduced-fat chicken patties. Reduced-fat chicken patties with 15% fat and 2% wheat sprout had textural properties and sensory characteristics similar to control patties containing regular-fat level (20%). Thus, 15% fat reduced-fat chicken patties with an addition of 2% wheat sprout can improve the quality and sensory characteristics of reduced-fat chicken patties so that they can be acceptable to consumers.

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References

- An, K. I., Choi, J. H., Choi, Y. S., Han, D. J., Kim, H. Y., Lee, M. A., Kim, S. Y., Kim, T. H., and Kim, C. J. (2010) Effects of kimchi powder on quality characteristics of semi-dried pork jerky. *Korean J. Food Sci. An.* **30**, 198-205.
- An, S. H. (2015) Quality characteristics of cookies made with added wheat sprout powder. *Korean J. Food Cook. Sci.* **31**, 687-695.
- AOAC. (2000) Official methods of analysis of AOAC, Vol. 41. (17th ed.). Washington DC: Association of Official Analytical Chemists.
- Bloukas, J. G. and Paneras, E. D. (1993) Substituting olive oil for pork backfat affects quality of low-fat frankfurters. *J. Food Sci.* **58**, 705-709.
- Bourne, M. C. (1978) Texture profile analysis. *Food Technol.* **32**, 62-66.
- Cengiz, E. and Gokoglu, N. (2005) Changes in energy and cholesterol contents of frankfurter-type sausages with fat reduction and fat replacer addition. *Food Chem.* **91**, 443-447.
- Choi, M. S., Choi, Y. S., Kim, H. W., Hwang, K. E., Song, D.

- H., Lee, S. Y., and Kim, C. J. (2014a) Effects of replacing pork back fat with brewer's spent grain dietary fiber on quality characteristics of reduced-fat chicken sausages. *Korean J. Food Sci. An.* **34**, 158-165.
8. Choi, Y. S., Choi, J. H., Han, D. J., Kim, H. Y., Kim, H. W., Lee, M. A., Chung, H. J., and Kim, C. J. (2012) Effects of *Laminaria japonica* on the physico-chemical and sensory characteristics of reduced-fat pork patties. *Meat Sci.* **91**, 1-7.
9. Choi, Y. S., Choi, J. H., Han, D. J., Kim, H. Y., Lee, M. A., Jeong, J. Y., Chung, H. J., and Kim, C. J. (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.
10. Choi, Y. S., Choi, J. H., Han, D. J., Kim, H. Y., Lee, M. A., Kim, H. W., and Kim, C. J. (2009) Characteristics of low-fat meat emulsion systems with pork fat replaced by vegetable oils and rice bran fiber. *Meat Sci.* **82**, 266-271.
11. Choi, Y. S., Choi, J. H., Kim, H. Y., Kim, H. W., Lee, M. A., Chung, H. J., Lee, S. K., and Kim, C. J. (2011) Effect of lotus (*Nelumbo nucifera*) leaf powder on the quality characteristics of chicken patties in refrigerated storage. *Korean J. Food Sci. An.* **31**, 9-18.
12. Choi, Y. S., Jeong, J. Y., Choi, J. H., Han, D. J., Kim, H. Y., Lee, M. A., Kim, H. W., Paik, H. D., and Kim, C. J. (2008) Effects of dietary fiber from rice bran on the quality characteristics of emulsion-type sausages. *Korean J. Food Sci. An.* **28**, 14-20.
13. Choi, Y. S., Kim, H. W., Hwang, K. E., Song, D. H., Choi, J. H., Lee, M. A., Chung, H. J., and Kim, C. J. (2014b) Physico-chemical properties and sensory characteristics of reduced-fat frankfurters with pork back fat replaced by dietary fiber extracted from makgeolli lees. *Meat Sci.* **96**, 892-900.
14. Choi, Y. S., Kim, H. W., Hwang, K. E., Song, D. H., Jeong, T. J., Kim, Y. B., Jeon, K. H., and Kim, C. J. (2015) Effects of fat levels and rice bran fiber on the chemical, textural, and sensory properties of frankfurters. *Food Sci. Biotechnol.* **24**, 489-495.
15. Choi, Y. S., Lee, M. A., Jeong, J. Y., Choi, J. H., Han, D. J., Kim, H. Y., Lee, E. S., and Kim, C. J. (2007) Effects of wheat fiber on the quality of meat batter. *Korean J. Food Sci. An.* **27**, 22-28.
16. Chung, E. S. and An, S. H. (2015) Physicochemical and sensory characteristics of muffins added with wheat sprout powder. *Korean J. Culinary Res.* **21**, 207-220.
17. Crehan, C. M., Hughes, E., Troy, D. J., and Buckley, D. J. (2000) Effects of fat level and maltodextrin on the functional properties of frankfurter formulated with 5, 12 and 30% fat. *Meat Sci.* **55**, 463-469.
18. Hand, L. W., Hollingsworth, C. A., Calkins, C. R., and Mandigo, R. W. (1987) Effects of preblending, reduced fat and salt levels on frankfurter characteristics. *J. Food Sci.* **52**, 1149-1151.
19. Hughes, E., Cofrades, S., and Troy, D. J. (1997) Effects of fat level, oat fiber and carrageenan on frankfurters formulated with 5, 12 and 30% fat. *Meat Sci.* **45**, 273-281.
20. Kim, H. W., Hwang, K. E., Song, D. H., Lee, S. Y., Choi, M. S., Lim, Y. B., Choi, J. H., Choi, Y. S., Kim, H. Y., and Kim, C. J. (2013) Effects of dietary fiber extracts from brewer's spent grain on quality characteristics of chicken patties cooked in convective oven. *Korean J. Food Sci. An.* **33**, 45-52.
21. Lawless, H. T. and Heymann, H. (1999) Sensory evaluation of food: Principles and practices. New York: Chapman & Hall, An Aspen Publication.
22. Lee, M. A., Han, D. J., Jeong, J. Y., Choi, J. H., Choi, Y. S., Kim, H. Y., Paik, H. D., and Kim, C. J. (2008) Effect of kimchi powder level and drying methods on quality characteristics of breakfast sausage. *Meat Sci.* **80**, 708-714.
23. Mansour E. H. and Khalil, A. H. (1999) Characteristics of low-fat beefburgers as influenced by various types of wheat fibres. *J. Sci. Food Agri.* **79**, 493-498.
24. Park, L., Y. (2015) Quality characteristics of muffins containing wheat sprout powder. *J. Korean Soc. Food Sci. Nutr.* **44**, 784-789.
25. Pongrac, P., Potisek, M., Fras, A., Likar, M., Budic, B., Myszk, K., Boros, D., Necemer, M., Kelemen, M., Vavpetic, P., Pelicon, P., Vogel-Mikus, K., Regvar, M., and Kreft, I. (2016) Composition of mineral elements and bioactive compounds in tartary buckwheat and wheat sprouts as affected by natural mineral-rich water. *J. Cereal Sci.* **69**, 9-16.
26. Salcedo-Sandoval, L., Cofrades, S., Ruiz-Capillas Perez, C., Solas, M. T., and Jimenez-Colmenero, F. (2012) Healthier oils stabilized in konjac matrix as fat replacers in n-3 PUFA enriched frankfurters. *Meat Sci.* **93**, 757-766.
27. SAS (2011) SAS user's guide: Basic statistical analysis. NC, USA: Statistical Analysis Systems Institute.
28. Turhan, S., Sagir, I., and Ustun, N. S. (2005) Utilization of hazelnut pellicle in low-fat beef burgers. *Meat Sci.* **71**, 312-316.
29. Vural, H., Javidipour, I., and Ozbas, O. O. (2004) Effects of interesterified vegetable oils and sugarbeet fiber on the quality of frankfurters. *Meat Sci.* **67**, 65-72.
30. Zhuang, X., Han, M., Kang, Z. I., Wang, K., Bai, Y., Xu, X. I., and Zhou, G. H. (2016) Effects of the sugarcane dietary fiber nad pre-emulsified sesame oil on low-fat meat batter physicochemical property, texture, and microstructure. *Meat Sci.* **113**, 107-115.