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ARTICLE

The Quality Characteristics of Salted Ground Pork Patties Containing Various Fat Levels by Microwave Cooking

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Abstract

This study was carried out to evaluate the effects of fat level on the microwave cooking properties of ground pork patties with NaCl (1.5%). Ground pork patties were processed from pork hams to achieve fat levels of 10%, 15%, 20%, and 25%, respectively. Each patty was cooked from a thawed state to 75°C in a microwave oven at full power (700 W). After microwave cooking, protein content, moisture content, fat retention, and shear force values in patties decreased as fat level increased from 10 to 25%. As fat level increased, cooking time decreased but total cooking loss and drip loss were increased, whereas slight differences in diameter reduction and thickness of patties were observed. In raw patties, 10% fat patties had lower L* values and higher a* values compared to patties with more fat, but these differences were reduced when patties were cooked. Patties with 10% fat showed a more pink color on the surface and interior than patties with a higher fat content but more air pockets were noted in higher-fat patties. Higher-fat patties were more tender, juicy, and oily than lower-fat patties.

Keywords: ground pork patties, fat level, microwave cooking, NaCl, cooking properties

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Introduction

Microwave processes are increasingly accepted by modern households and the food industry globally (Decareau, 1985; Mudgett, 1989; Puligundla *et al.*, 2013; Vadivambal and Jayas, 2010) and are widely used for various processing operations such as cooking, blanching, drying, pasteurizing, and thawing of various food products (Chandrasekaran *et al.*, 2013; Decareau, 1985; Mudgett, 1989; Puligundla *et al.*, 2013).

In food materials, microwave cooking mainly occurs due to dipolar and ionic mechanisms. The presence of moisture or water causes dielectric heating due to the dipolar nature and molecular friction of water (Chandrasekaran *et al.*, 2013; Gunasekaran, 2002; Mudgett, 1989). In addition, dissolved salt within foods can act as a conductor in an electromagnetic field (Ryyänen, 1995). Both the water and salt content of foods largely determine the dielectric properties, which affect microwave penetration depth, conventional heat transfer, and overall heating rate (Mudgett, 1986; Mudgett, 1989). Thus, the ability to convert microwave energy to heat requires the most basic dielectric properties of food components and the electric field. The dielectric constant expresses the capacity of food to store electrical energy (Engelder and Buffler, 1991; Ryyänen, 1995), and the dielectric loss factor describes its ability to dissipate electrical energy (Mudgett, 1986; Ryyänen, 1995). Generally, the greater moisture and salt content increase the dielectric loss factor of foods and heating is more rapid while the penetration depth is lowered and the uniformity of the heating rate is reduced, thereby resulting in more pronounced surface heating (Ohlsson and Bengtsson, 2001; Schiffmann, 1986). On the other hand, products with lower moisture may heat more uniformly because of their low heat capacities (Schiffmann, 1986; Schiffmann, 1990). Fat, a food component, is also dipolar component and may affect the cooking rate in a microwave field (Gunasekaran, 2002). Fat has relatively lower dielectric properties than water in food, but the cooking rate may increase with fat content due to the low specific heat capacity of fat compared to that of water (Ohlsson and Bengtsson, 2001; Picouet *et al.*, 2007; Schiffmann, 1990). Consequently, food composition is related

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to the electrical properties in a microwave field, which affect the cooking behavior and cooking properties of food (Jeong *et al.*, 2004; Jeong *et al.*, 2007; Ryyänen and Ohlsson, 1996).

Some studies have assessed the effect of composition on the physicochemical and sensory characteristics of ground meat products by conventional cooking (Berry, 1992; Berry, 1993; Berry, 1994; Berry, 1998; Bigner and Berry, 1997; Cross *et al.*, 1980; Dreeling *et al.*, 2000; Dreeling *et al.*, 2002; Keeton, 1983; Parizek *et al.*, 1981; Suman and Sharma, 2003; Troutt *et al.*, 1992; van Laack *et al.*, 1996; Young *et al.*, 1991), by microwave cooking (Das and Rajkumar, 2013; Jeong *et al.*, 2004; Jeong *et al.*, 2007; Picouet *et al.*, 2007; Ryyänen *et al.*, 2004), and both cooking methods (Cannell *et al.*, 1989; Kirchner *et al.*, 2000; Mohammad *et al.*, 2010). In general, the composition, especially fat level, influences the cooking properties of ground patties as well as their overall qualities and the sensory characteristics of the final product. In microwave cooking, Das and Rajkumar (2013) prepared goat meat patties with refined vegetable oil to achieved fat levels of 5, 10, 15, and 20%, and found that the shear force value decreased as fat level increased and the subjective color in 5% fat patties was darker and redder compared to patties with other fat contents. Further, Jeong *et al.* (2004) assessed the effects of fat level on the cooking properties of ground pork patties cooked by microwave energy. Although some researchers have attempted to evaluate the microwave cooking properties of ground meat products as influenced by fat content, far less data are available on the factors that influence the quality properties and sensory attributes of salt-containing ground patties with different fat levels. Salt in meat mixtures will achieve the necessary ionic strength that is critical to solubilization and extraction of the salt-soluble proteins (Sebranek, 2009). In addition, since combined effects on dissolved salt and fat rather than fat alone as a single ingredient can produce significant changes in the microwave cooking patterns and qualities of meat products, understandings of microwave cooking for products containing salt are needed to improve efficient microwave cooking processes. Therefore, the objective of this study was to evaluate the effect of fat level on the microwave cooking properties of ground pork patties containing NaCl.

Materials and Methods

Processing and preparation

Six fresh pork hams, weighing 6.8-7.2 kg each, were purchased from a local processor at 48 h post mortem. Pork back fat was also collected. All subcutaneous and intermuscular fat and visible connective tissue were removed from the fresh ham muscles. Lean materials were initially ground through a 13 mm plate and fat percentage was determined prior to blending. The pork fat was ground though an 8 mm plate and added to the lean meat to achieve fat levels of 10%, 15%, 20%, and 25%, respectively. During the patty manufacturing, 1.5% NaCl was incorporated into meat mixture with each fat level. The mixtures from each batch were mixed by hand for 3 min and subjected to two final grindings (3 mm plate). The ground mixtures were hand-mixed and then formed into patties (90 g each) using sterile 15×90 mm Petri dishes. Patties were then packaged with Nylon/PE film, frozen and stored at -25°C until testing. Pork patty processing was performed in triplicate for each treatment.

Microwave cooking procedure

Patties were cooked in a household-type microwave oven (Model RE-M400, Samsung Electronics Co. Ltd., Korea) at full power (700 W), operating at 2450 MHz. Patties containing various fat levels with NaCl were held and thawed at 2-3°C for 24-36 h before cooking. Each patty was placed in the center of the oven, on a microwave-safe plastic container (uncovered) with a plastic rack (approximately 8 mm from the bottom of the container), which allowed drips to escape from the underside, until the center of the patty reached the designated testing temperature (75°C). The container was rotated inside the microwave chamber during the cooking period. The internal temperature of the cooked samples was obtained using a digital thermometer (TES-1305, Tes Electrical Corp., Taiwan) by inserting an iron-constantan thermocouple probe into the geometric center of the patty immediately after removal from the oven. Preliminary time-temperature trials were conducted to determine the cooking time needed to reach the designated internal temperature. The oven was turned off before an internal temperature of 75°C was reached, and a short period was allowed for the temperature to rise (Berry and Bigner-George, 2001; Jeong *et al.*, 2009; Knutson *et al.*, 1987). If the temperature did not reach 75°C, further cooking was performed to achieve the desired temperature. After the temperature was achieved, the container including the patty and then the patty alone were immediately weighed to determine cooking loss.

pH value measurements

For pH value measurements, raw patties were thawed following a procedure described previously and samples from cooked patties were removed immediately upon completion of cooking. The pH value of each patty was determined using a pH meter (Model 340, Mettler-Toledo GmbH Analytical, Switzerland) following blending a 5 g sample with 20 mL distilled water for 60 s in a homogenizer (Ultra-Turrax® T25, Janke & Kunkel, Germany).

Proximate composition analysis

Proximate analyses were determined using AOAC (2000) methods. Moisture content was determined by weight loss after 12 h of drying at 105°C in a drying oven (SW-90D, Sang Woo Scientific Co., Korea). Fat content was determined with a solvent extraction system (Soxtec® Avanti 2050 Auto System, Foss Tecator AB, Sweden) and protein content was determined with an automatic Kjeldahl nitrogen analyzer (Kjeltec® 2300Analyzer Unit, Foss Tecator AB, Sweden).

Fat retention after cooking was calculated using the following formula:

$$\%\text{ fat retention} = \frac{\text{Weight of cooked sample} \times \%\text{ fat of cooked sample}}{\text{Weight of raw sample} \times \%\text{ fat of raw sample}} \times 100$$

Cooking rate and cooking loss measurements

Total cooking loss, drip loss, evaporation loss, and evaporation ratio were determined as follows:

$$\text{Total cooking loss (\%)} = \frac{\text{Weight of raw sample} - \text{Weight of cooked sample}}{\text{Weight of raw sample}} \times 100$$

$$\text{Drip loss (\%)} = \frac{\text{Drip weight}}{\text{Weight of raw sample}} \times 100$$

$$\text{Evaporation loss (\%)} = \text{Total cooking loss (\%)} - \text{Drip loss (\%)}$$

$$\text{Evaporation ratio (\%)} = \frac{\text{Drip weight}}{\text{Weight of raw sample}} \times 100$$

The thickness and diameter of raw and cooked patties were recorded using Vernier calipers (530-122, Mitutoyo, Japan) and measured as described by Jeong *et al.* (2009). Percent reduction in patty thickness and diameter was determined using the following equation:

$$\text{Reduction in patty thickness (\%)} = \frac{\text{Thickness of raw patty} - \text{Thickness of cooked patty}}{\text{Thickness of raw patty}} \times 100$$

$$\text{Reduction in patty diameter (\%)} = \frac{\text{Diameter of raw patty} - \text{Diameter of cooked patty}}{\text{Diameter of raw patty}} \times 100$$

Shear force measurements

Patties were cooked according to procedures described previously, and then equilibrated to room temperature for 1 h prior to analysis. Each patty was cut with a knife into 2.5 cm wide sections and the sections were sheared in two separate locations with a Warner-Bratzler blade set attached to a Texture Analyzer (TA-XT2*i*, Stable Micro System Ltd., UK). Test speeds were set at 2 mm/s. The shear force values to obtain the maximum force required to shear through each sample were collected and analyzed and expressed as shear force (N).

Visual and Instrumental color evaluations

Immediately following cooking and weighing, cooked patties were sliced parallel to the flat surface from one side of the patty. The surface and internal color of each cooked patty was evaluated by a six-member trained panel using an 8-point hedonic scale (1 = grayish pink, 8 = tanned white). The amount of air pockets visible on the cut surface was also evaluated (1 = none, 8 = extremely numerous). Instrumental color values (CIE L*, a*, and b* values) were measured on the surface of each patty before cooking, and on the surface and on a cut surface (internal) after cooking, using a Minolta Chroma meter CR-200 (illuminate C, calibrated with white plate, L*=+97.83, a*=-0.43, b*=+1.98).

Sensory evaluations

Sensory evaluations were performed, in duplicate, on each patty with each of the five fat levels by a six-member trained panel. Panelists were informed according to methodology proposed by ISO regulations (KS Q ISO, 2003; KS Q ISO, 2009) with the attributes and the scale to be used. Samples were cooked as described previously. Immediately after cooking, patties were cut into eight equal-sized wedges and served to each panelist. Panelists were given warm water (30°C) to consume between samples. Patties were evaluated for flavor, tenderness, juiciness, and oiliness on an 8-point hedonic scale (Cross *et al.*, 1978). The scale includes the followings: 1 = extremely undesirable and 8 = extremely desirable for flavor; 1 = extremely tough and 8 = extremely tender for tenderness; 1 = extremely dry and 8 = extremely juicy for juiciness; 1 = no oily feeling and 8 = extremely oily for oiliness.

Statistical analysis

The experiment was replicated three times. Data were subjected to one-way analysis of variance using the General Linear Model (GLM) procedure of the SAS statistical package (SAS, 1999). The Duncan's multiple range test ($p<0.05$) was used to determine differences between mean values of treatments.

Results and Discussion

pH values and compositional properties

The pH values and compositional properties of raw and cooked ground pork patties containing 10% to 25% fat with 1.5% NaCl are shown in Table 1. The pH values of raw and cooked patties were not affected by fat levels, as reported by Jeong *et al.* (2004). In raw ground patties, fat contents were slightly higher than designated levels and significantly increased ($p<0.05$) with increasing fat level, as expected. Protein and moisture contents of raw ground patties decreased as fat level increased, probably due to the dilution effect. These results are consistent with the findings of Troutt *et al.* (1992) for ground beef patties and Jeong *et al.* (2004) for ground pork patties. Das and Rajkumar (2013) also reported for goat meat patties processed with 5 to 20% fat that patties containing higher fat levels had lower moisture and protein contents compared to those with lower fat levels. After cooking, fat levels affected the chemical composition of ground pork patties (Table 1), which is generally supported by previous studies by both conventional cooking (Berry, 1992; Cannell *et al.*, 1989; Troutt *et al.*, 1992) and microwave cooking (Das and Rajkumar, 2013; Jeong *et al.*, 2004), although they formulated meat patties without salt. In this study, cooked patties with 25% fat had higher ($p<0.05$) fat contents than those with 10% and 15% fat, but were not significantly different ($p>0.05$) from 20% fat patties. The protein content of the cooked patties was greater than that of the raw patties, which could be caused by moisture loss from the products. Jeong *et al.* (2007) obtained similar results for ground pork patties containing 10% or 20% fat with/without salt cooked in a microwave oven. In the present study, 10% fat patties had higher ($p<0.05$) protein contents compared to patties with 25% fat, but neither patties with 10% fat nor with 25% fat was different ($p>0.05$) in protein contents from those with 15% or 20% fat. Moisture contents in cooked ground pork patties decreased with increasing fat level. Patties with 10% or 15% fat exhibited higher ($p<0.05$) moisture contents than those with 20% to 25% fat. Jeong *et al.* (2004) reported that lower-fat patties had higher moisture contents than those with more fat, but no differences in moisture contents were observed between 20% and 25% fat patties. This is similar to our result, although salt was incorporated in products in our study. Fat retention decreased ($p<0.05$) from 76.70% to 43.49% in cooked ground pork patties as fat level increased from 10% to 25%. This was observed previously by several studies (Berry, 1992; Bigner and Berry, 1997; Dreeling *et al.*, 2002; Rhee *et al.*, 1993) for conventional cooking methods. Similarly, for microwave cooking, Cannell *et al.* (1989) reported that fat retention decreased from 82.21% to 42.22% when ground beef with 10% to 25% fat level was cooked to 80°C, and Jeong *et al.* (2004) also reported that fat retention of ground pork patties cooked to 75°C was significantly decreased with increasing fat level.

Table 1. pH values and compositional properties of raw and cooked ground pork patties containing 10% to 25% fat with 1.5% NaCl

Property	Fat level (%)			
	10	15	20	25
Raw patty				
pH	5.74±0.01	5.73±0.01	5.74±0.02	5.73±0.01
Fat content (%)	11.19±0.84[d]	16.10±0.47[c]	21.33±0.62[b]	26.04±0.74[a]
Protein content (%)	20.06±0.34[a]	18.34±0.51[b]	17.17±0.16[c]	15.96±0.07[d]
Moisture content (%)	66.05±0.07[a]	62.96±0.19[b]	60.28±0.15[c]	56.97±0.19[d]
Cooked patty				
pH	6.02±0.01	6.03±0.01	6.04±0.01	6.03±0.02
Fat content (%)	12.17±0.53[c]	14.79±0.64[b]	16.16±0.34[ab]	17.32±0.77[a]
Protein content (%)	25.38±0.60[a]	24.91±0.47[ab]	24.16±0.19[ab]	23.69±0.17[b]
Moisture content (%)	59.68±0.50[a]	58.67±0.07[a]	57.29±0.14[b]	56.61±0.45[b]
Fat retention (%)	76.70±2.84[a]	65.59±2.19[b]	53.05±1.41[c]	43.49±0.66[d]

All values are means±standard error of three replicates.

[a-d]Means sharing different letters in the same row are significantly different ($p<0.05$).

Table 2. Cooking properties and shear force values of cooked ground pork patties containing 10% to 25% fat with 1.5% NaCl

Property	Fat level (%)			
	10	15	20	25
Cooking time (s)	150.66±1.91[a]	144.38±2.00[b]	143.98±1.55[b]	123.59±1.53[c]
Total cooking loss (%)	23.38±0.13[d]	24.18±0.18[c]	27.38±0.17[b]	27.88±0.17[a]
Cooking drip (%)	8.10±0.10[d]	9.17±0.14[c]	12.22±0.15[b]	16.34±0.12[a]
Evaporation loss (%)	15.29±0.14[a]	15.01±0.12[a]	15.16±0.09[a]	11.54±0.11[b]
Evaporation ratio (%)	65.37±0.41[a]	62.11±0.39[b]	55.40±0.35[c]	41.39±0.31[d]
Reduction in patty diameter (%)	21.29±0.23[b]	21.35±0.30[b]	23.12±0.27[a]	22.09±0.33[b]
Reduction in patty thickness (%)	13.77±0.50[b]	14.34±0.52[ab]	15.95±0.52[a]	15.68±0.58[a]
Shear force (N)	23.21±0.63[a]	15.79±0.52[b]	12.85±0.69[c]	10.13±0.49[d]

All values are means±standard error of three replicates.
[a-d]Means sharing different letters in the same row are significantly different ($p<0.05$).

Microwave cooking properties and shear force

The microwave cooking properties and shear force values of cooked ground pork patties containing 10% to 25% fat with NaCl are presented in Table 2. Fat levels in cooked ground pork patties affected the cooking time. Cooking time decreased ($p<0.05$) from 150 to 123 s as fat level increased from 10% to 25%. Similarly, Das and Rajkumar (2013) found that microwave cooking time in goat meat patties decreased as fat levels increased. Faster cooking in higher fat patties is likely due to effects on fat rather than water during microwave cooking. It could be speculated that an elevation of fat level in patties results in relatively lower moisture contents and dielectric properties, whereas the specific heat capacity of fats is much lower than that of water, resulting in more rapid heating (George and Burnett, 1991; Gunasekaran, 2002; Ohlsson and Bengtsson, 2001). However, cooking time in the present study was longer than that reported by Jeong *et al.* (2004), which ranged from 100 to 86 s. It appears that the presence of salt in ground pork patties may be responsible for the reduction of cooking rate by lowering penetration depth or increasing the shielding effect during microwave cooking (Chamchong and Datta, 1999; Jeong *et al*., 2007; Ohlsson and Bengtsson, 2001). As fat level in cooked pork patties increased, total cooking loss and drip loss increased ($p<0.05$), and were greatest ($p<0.05$) for patties with 25% fat (Table 2). In contrast, patties with 25% fat had the lowest ($p<0.05$) evaporation loss, and no differences ($p>0.05$) in evaporation loss for 10%, 15%, and 20% fat patties were observed. These results for total cooking loss are similar to Jeong *et al.* (2004) for ground pork patties containing various fat levels without salt, however, drip loss was less and evaporation loss was higher than those found in their study. These differences may be due to the reduction of drip loss by addition of salt (Jeong *et al*., 2007; Puolanne and Ruusunen, 1980; Ruusunen *et al.*, 2005). Surface evaporation is a pronounced characteristic of foods cooked in microwave oven and evaporation from the surface can occur when cooking is non-uniform (Decareau, 1992; Ni *et al.*, 1999). In this study, the evaporation ratio was highest ($p<0.05$) in 10% fat patties and decreased with fat levels (Table 2). The values were markedly higher than reported by Jeong *et al.* (2004). It seems likely that salt addition to the patties resulted in an increase in the non-uniformity of microwave cooking pattern and the edge effect (Anantheswaran and Liu, 1994; Jeong *et al.*, 2007). Patties with 20% fat had greater changes ($p<0.05$) in diameter than other fat patties, but there were no differences ($p>0.05$) in reduction in diameter among those with other fat levels (Table 2). The reduction of thickness in patties with 10% fat was less ($p<0.05$) compared to that in higher-fat patties (20% and 25%). This result is contrary to Jeong *et al.* (2004) who found that changes in thickness were less in high-fat patties (20% and 25%) without salt. However, Jeong *et al.* (2007) reported that patties processed with 20% fat had greater reduction in thickness than those with 10% fat, and thickness changes in patties were reduced by salt addition, which is in agreement with our findings. The shear force values of ground pork patties decreased ($p<0.05$) with increasing fat levels. Patties with 25% fat had the lowest ($p<0.05$) shear force values and the highest values were observed ($p<0.05$) in patties containing 10% fat. This is in agreement with Berry (1993), Das and Rajkumar (2013), Jeong *et al.* (2004), and Troutt *et al.* (1992), who found that patties with higher fat contents had lower shear force values than those with lower fat contents.

Instrumental and visual color evaluation

The instrumental color evaluation of raw and cooked ground pork patties containing 10% to 25% fat with 1.5% NaCl is presented in Table 3. In raw patties, L* values were highest ($p<0.05$) for 25% fat patties and lowest ($p<0.05$) for 10% fat patties. Similar results have been reported by others (Dreeling *et al.*, 2002; Jeong *et al.*, 2004; Troutt *et al.*, 1992). Patties with 10% fat had higher ($p<0.05$) a* values compared to those with more fat, and there were no differences ($p>0.05$) in a* values among patties with 15%, 20%, and 25% fat. Conversely, b* values were lowest ($p<0.05$) for patties with 10% fat, but b* values in patties with 15%, 20%, and 25% fat were not different ($p>0.05$), as was reported by Jeong *et al.* (2004).

In the cooked patties (Table 3), fat level had no effect ($p>0.05$) on the surface color values (L*, a*, b*). However, regarding the internal color, patties with 10% and 15% fat had higher ($p<0.05$) L* values than those with 20% and 25% fat, and no differences ($p>0.05$) in L* values were observed between patties with 10% and 15% fat or those with 20% and 25% fat. Fat levels did not affect ($p>0.05$) a* values of the internal color of cooked patties. Patties with 25% fat had the highest ($p<0.05$) b* values, and the lowest values ($p<0.05$) were obtained for 10% fat patties. No differences ($p>0.05$) were found between patties with 15% fat and 20% fat. These results for a* and b* values are similar to Jeong *et al.* (2004), who reported that a* values in internal color were not significantly different between patties with various fat contents, and high-fat patties had higher b* values than lower-fat patties.

In the visual evaluations of cooked ground pork patties containing various fat levels (Table 4), the surface color score was lowest ($p<0.05$) in patties containing 10% fat, but the ratings of patties with higher fat levels were similar ($p>0.05$). Internal color became increasingly tan white ($p<0.05$) as fat level increased, and patties with 20% and 25% fat showed the highest scores ($p<0.05$). Our surface and internal color results are not in agreement with those of previous studies (Jeong *et al.*, 2004; Troutt *et al.*, 1992), which found that fat level did not affect the surface color and internal color of cooked ground pork patties or beef patties. This discrepancy may be related to our addition of 1.5% NaCl. Since the addition of salt to patties could increase the non-uniformity of the temperature profile (Chamchong and Datta, 1999; Jeong *et al.*, 2007), such non-uniformity during microwave cooking may have affected the surface and internal color in the present study. The amount of air pockets in cooked pork patties increased ($p<0.05$) with fat levels (Table 4). The highest scores ($p<0.05$) were obtained in patties with 25% fat and the lowest ($p<0.05$) in those with 10% fat. Similarly, Troutt (1992) reported that patties with lower levels of fat had signifi-

Table 3. CIE L*, a*, b* values of raw and cooked ground pork patties containing 10% to 25% fat with 1.5% NaCl

Property	Fat level (%)			
	10	15	20	25
Raw patty				
L*	56.84±0.41[c]	61.00±0.28[b]	61.46±0.31[b]	63.33±0.48[a]
a*	9.34±0.18[a]	8.42±0.07[b]	8.62±0.10[b]	8.69±0.27[b]
b*	10.02±0.20[b]	10.92±0.04[a]	11.14±0.06[a]	11.05±0.10[a]
Cooked patty (surface)				
L*	57.97±0.80	57.95±0.76	58.17±0.65	59.47±0.59
a*	6.46±0.35	6.39±0.38	6.13±0.33	6.10±0.29
b*	8.84±0.28	9.38±0.36	8.87±0.25	8.94±0.22
Cooked patty (internal)				
L*	64.87±0.16[a]	64.63±0.19[a]	63.76±0.33[b]	63.44±0.24[b]
a*	5.75±0.04	5.60±0.09	5.56±0.08	5.54±0.06
b*	7.41±0.03[c]	7.60±0.05[b]	7.55±0.06[b]	7.73±0.03[a]

All values are means±standard error of three replicates.
[a-c]Means sharing different letters in the same row are significantly different ($p<0.05$).

Table 4. Visual evaluations of cooked ground pork patties containing 10% to 25% fat with 1.5% NaCl

Property[1]	Fat level (%)			
	10	15	20	25
Surface color	5.50±0.10[b]	6.36±0.10[a]	6.27±0.10[a]	5.91±0.13[a]
Internal color	4.42±0.10[c]	5.04±0.14[b]	5.67±0.12[a]	6.00±0.15[a]
Amount of air pockets	3.25±0.12[d]	4.92±0.10[c]	5.75±0.09[b]	6.83±0.12[a]

All values are mean±standard error of three replicates.
[a-d]Means sharing different letters in the same row are significantly different ($p<0.05$).
[1]Scores based on an 8-point scale, where 1 = grayish pink and none, and 8 = tan white and extremely numerous.

Table 5. Sensory attributes of cooked ground pork patties containing 10% to 25% fat with 1.5% NaCl

Property[1]	Fat level (%)			
	10	15	20	25
Flavor	6.17±0.14[c]	6.25±0.11[bc]	6.58±0.10[ab]	6.88±0.14[a]
Tenderness	4.58±0.23[c]	5.67±0.10[b]	6.67±0.13[a]	6.92±0.10[a]
Juiciness	5.33±0.10[c]	5.58±0.10[c]	6.00±0.12[b]	6.58±0.10[a]
Oiliness	4.58±0.10[d]	5.08±0.08[c]	5.87±0.11[b]	6.50±0.13[a]

All values are means±standard error of three replicates.
[a-d]Means sharing different letters in the same row are significantly different ($p<0.05$).
[1]Scores based on an 8-point scale, where 1 = extremely undesirable and 8 = extremely desirable for flavor; 1 = extremely tough and 8 = extremely tender for tenderness; 1 = extremely dry and 8 = extremely juicy for juiciness; 1 = no oily feeling and 8 = extremely oily for oiliness.

cantly fewer air pockets than higher-fat patties.

Sensory evaluation

The sensory evaluation of ground pork patties containing various fat levels cooked by microwave is shown in Table 5. Overall, flavor, tenderness, juiciness, and oiliness were significantly affected by fat level. Regarding flavor and tenderness, patties with 20% and 25% fat had higher scores ($p<0.05$) than 10% fat patties, and they were not different ($p>0.05$) from each other. Higher-fat patties (20% or 25% fat) were juicier ($p<0.05$) compared to lower-fat patties (10% or 15%). Similar results have been reported by others (Cross *et al.*, 1980; Das and Rajkumar, 2013; Jeong *et al.*, 2004; Keeton, 1983; Kregel *et al.*, 1986) for ground meat products in either conventional or microwave cooking. The ratings of oiliness in cooked patties increased ($p<0.05$) as fat level increased, which was similar to the trends in fat contents in this study. Dreeling *et al.* (2002) also found that high-fat beef burgers had significantly higher fattiness scores than low-fat burgers.

Conclusion

In conclusion, the fat level in ground pork patties affected the compositional and cooking properties and sensory evaluations when patties were cooked in a microwave oven. Lower-fat patties had a longer cooking time and higher evaporation ratio but less total cooking loss and drip loss compared to higher fat patties. However, the effects of fat level on instrumental color values in cooked patties were relatively limited. The visual and sensory evaluations revealed that an increase in fat level caused increased tan white color, tenderness, juiciness, and oiliness of cooked patties. With fat effects for microwave cooking, the presence of salt in the patties could increase the nonuniformity of the microwave cooking pattern and affect the cooking properties. Further research on microwave cooking to find the effects of other compositional factors, including other ingredients should be done to improve the quality properties of ground meat products.

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