QUALITY CHARACTERISTICS OF COOKED GROUND PORK PATTIES AS AFFECTED BY PERFORATION AND FAT LEVEL

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***Abstract*—This study was conducted to investigate the effect of perforation treatment on cooking, color, textural, and visual properties of cooked ground pork patties made with 10% fat or 20% fat. Each patty was treated with the combinations of size (4 or 8 mm diameters) and number (three or six) of hole (the radial distances of 2.5-cm from center position). Resulting treatments for each fat level were: no-hole (control), three 4-mm holes (S4N3), six 4-mm holes (S4N6); three 8-mm holes (S8N3); six 8-mm holes (S8N6). Cooking time decreased as hole size or number increased at either level of fat (10%, 20%). Perforation treatment did not affect cooking and textural properties of ground pork patties with 10% fat. However, patties containing 20% fat showed more change in diameter but less reduction in thickness during cooking by perforation treatment, and there were no differences in hardness and springiness between perforated and control patties. Compared with 10% fat patties, 20% fat patties tended to be less cooking loss and hardness and more change in thickness regardless of the presence of perforation. The surface color (CIE *L**, *a**, and *b**) of cooked ground pork patties were not affected by perforation or fat levels, although S4N6 and S8N6 patties with 10% fat had lower *L** values. In the visual evaluations, surface color was rated generally higher scores (more tan) for 10% fat patties, while 20% fat patties showed lower scores in internal color than the control patties of each fat level.**

***Index Terms*— Fat level, Ground pork patties, Perforation, Quality characteristics.**

I. INTRODUCTION

Many factors can affect the cooking and textural properties, and consumer palatability of ground patties including fat level and surface treatment. Fat is a major determinant of the sensory characteristics in foods and its levels also influence the physicochemical properties of ground patties (Colmenero, 1996; Dreeling, Allen & Butler, 2002; Jeong, Lee, Paik, Choi & Kim, 2004; Jeong et al, 2007). Jeong et al. (2004) reported that cooking loss and the changes of diameter were higher for high fat patties than low fat patties, but changes in patty thickness and shear force values decreased as fat level increased.

During patty formation procedures, it is common industry practice to perforate the surface of patties with a knife or waffle or impress on each surface (Cross & Berry, 1980; Berry & Liu, 1998). Previous research has attempted to examine if the surface treatment had an effect on the improvement of cooking properties and palatability of ground beef patties (Berry & Liu, 1998). Berry and Liu (1998) found that patties subjected to surface perforations had shorter cooking time, but did not appreciably differ in cooking yield from nonperforated patties and had more shrink in patty diameter. Cross and Berry (1980) also reported that there are no advantage to subjecting the surface of the patty to a knife or waffle treatment. However, perforation method by punching holes through ground patty is not yet established. Therefore, the objective of this study was to evaluate the perforation (hole size and number) effects on cooking, color, textural, and visual properties of cooked ground pork patties made with 10% fat or 20% fat.

II. MATERIALS AND METHODS

A. Patty processing and perforation treatment

Six fresh pork hams, weighing 6.8-7.2 kg each, were purchased from a local processor at 48 h postmortem. 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 on raw materials using a solvent extraction system (Soxtec® Avanti 2050 Auto System, Foss Tecator AB, Höganas, Sweden) before blending in order to determine the amount required to achieve the desired fat level in the patties. The pork fat was ground through an 8 mm plate and added to the lean meat to achieve fat levels of 10% and 20%. The

mixtures from both of fat level (each 16 kg batch) were mixed by hand for 3 min and subjected to 2 final grindings (3 mm plate). The ground mixtures were hand-mixed and then stuffed into a fibrous casing (90-mm diameter) that was sectioned into approximate 25 cm lengths chubs. The chubs were frozen and stored at –20 °C for 24 hr and then sliced into patties (90 mm in diameter, 13 mm in thickness, each weighing about 100 g). The patties from each fat level were vacuum-packaged in an oxygen-impermeable bag and individually consisted of 15 packages containing 10 samples each, and held at 4 °C for 24 to 36 h prior to perforation treatment. After packages were opened, each patty was randomly selected, placed on a polyfoam tray, and then treated with either size (4 or 8 mm diameters) of metal punches (the radial distances of 2.5-cm from center position). Five perforation treatments for each fat level were: no-hole (control), three 4-mm holes (S4N3), six 4-mm holes (S4N6), three 8-mm holes (S8N3), and six 8-mm holes (S8N6).

B. Cooking procedure

The treated patties were cooked on a preheated electric grill (Model CG20, Hobart Corporation, Troy, OH, USA) at a surface temperature of 150 °C until the internal temperature reached 76.7 °C. Patties were cooked on one side for 2 min and the opposite side for 2 min, and thereafter flipped over every min until the target temperature was reached. The internal temperature of the patties was monitored with a digital thermometer (Model Tes-1305, Tes Electrical Corp., Taipei, Taiwan) by inserting an iron constantan thermocouple into the geometric center. Preliminary time-temperature trials were conducted to determine the length of cooking time needed to reach the designated internal temperature. Final cooking times were: control = 8 min 30 sec; S4N3 = 8 min 5 sec; S4N6 = 7 min 45 sec; S8N3 = 7 min 21 sec; S8N6 = 7 min 19 sec for 10% fat patties, control = 7 min 49 sec; S4N3 = 7 min 30 sec; S4N6 = 7 min 21 sec; S8N3 = 6 min 44 sec; S8N6 = 6 min 38 sec for 20% fat patties. After the temperature was achieved, the patties were held for 30 min at room temperature before determination of cooking properties.

C. Analysis

Cooking measurements. Cooking measurements were conducted on 15 patties/treatment/fat level and cooking loss was determined by calculating the weight differences for patties before and after cooking as follows: [(Raw weight - Cooked weight)/Raw weight × 100]. The thickness and the diameter of raw and cooked patties were recorded using Vernier Calipers. Two identified locations per patty, one in each of the half of the patty, were used for determining raw and cooked patty thickness measurements. Percent reduction in patty thickness was determined using the following equation: [(Raw patty thickness - cooked patty thickness)/Raw patty thickness × 100]. Two measurements per patty were taken to obtain raw and cooked patty diameters, using marked locations 90° from each other. Percent reduction in patty diameter was determined using the following equation: [(Raw patty diameter - cooked patty diameter)/Raw patty diameter × 100].

Texture profile analysis. Five patties/treatment/fat level were cooked according to the procedures previously described, and then equilibrated to room temperature for 1 h before sampling. Texture profile analysis (TPA) was performed with a texture analyzer (TA-XT2*i*; Stable Micro Systems, Surrey, England) at room temperature. Three measurements from different locations at each of sample were taken. The conditions of texture analysis were as follows: pre-test speed 2.0 mm/sec, post-test speed 5.0 mm/sec, maximum load 2 kg, head speed 2.0 mm/sec, distance 8.0 mm, force 5 g. The calculation of TPA values was obtained by graphing a curve using force and time plots. Values for hardness (N), springiness, and cohesiveness were determined.

Instrumental and visual color evaluations. Five patties/treatment/fat level were used for color measurements. 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 ten-member trained panel using an 8-point hedonic scale (1 = grayish pink, 8 = tanned white). The amount of air pockets on the cut surface were also evaluated (1 = none, 8 = extremely numerous). Instrumental color values (CIE L^*, a^*, and b^* values) were measured on the surface of each cooked patty, using a colorimeter (Model CR-210, Minolta Corporation, Ltd., Osaka, Japan; illuminant C, calibrated with white plate, L^*= +97.83, a^*= -0.43, b^*= +1.98).

Statistical analysis. The experiment was replicated three times. Data were analyzed as a 5 × 2 factorial design with five perforation treatments (control, S4N3, S4N6, S8N3, or S8N6) and two fat levels (10% or 20% fat) using Proc Mixed procedure of SAS (2002). If significance was determined ($p < 0.05$) in the model, dependent variable means were separated using the Least Significant Difference procedure of SAS. Visual color evaluation data were pooled across panelists and were analyzed as previously described.

III. RESULTS AND DISCUSSION

Table 1 shows the cooking properties of cooked ground pork patties (10% or 20 % fat) treated with perforation. Patties with both levels of fat (10%, 20%) had a similar ($p > 0.05$) cooking loss compared to both controls regardless of perforation treatment. However, S4N3, S4N6, and S8N6 patties with 10% fat had greater ($p < 0.05$) cooking loss than those with 20% fat. Perforation treatment had no effect ($p > 0.05$) on percentage reduction in diameter of 10% fat patties, but significantly reduced the diameter in S4N3 and S8N3 patties with 20% fat compared to the control and both patties showed a greater reduction ($p < 0.05$) than 10% patties with the same perforation. Percentage reduction in thickness of 10% fat patties did not affected ($p > 0.05$) by perforation treatment. However, perforation treatment resulted in a less reduction in thickness in patties containing 20% fat but not in S4N6 patties. Nevertheless, fat levels affected reduction in patty thickness and 20% fat patties showed a greater reduction ($p < 0.05$) than 10% fat patties across all treatments.

Textural properties of cooked ground pork patties containing 10% or 20% fat with perforation treatments are shown in Table 2. Perforation treatment did not improve hardness of patties with both level of fat (10%, 20%). Compared with 20% fat patties, 10% fat patties had higher hardness values ($p < 0.05$) across all samples. However, springiness was not affected ($p > 0.05$) by fat levels and perforation treatment. Perforated patties with 10% or 20% fat were not different ($p > 0.05$) in cohesiveness from the control. In the control and S4N6 patties, cohesiveness were decreased ($p < 0.05$) as fat level increased and differences in cohesiveness by fat level were not observed ($p > 0.05$) in other patties.

The surface color of cooked ground pork patties with 10% fat or 20% fat with perforation are presented in Table 3. S4N6 and S8N6 patties with 10% fat had higher ($p < 0.05$) CIE L^* values than the control, but no significant ($p > 0.05$) differences were found in other perforated patties. However, L^* values in 20% fat patties were not affected ($p > 0.05$) by perforation treatment and there were no differences ($p > 0.05$) in CIE L^* values between 10% fat and 20% fat patties. Similarly, no differences ($p > 0.05$) in CIE a^* and b^* values of cooked ground patties were observed for any of the sizes and numbers of hole at any levels of fat in comparison to the control samples.

Table 4 shows the visual evaluations of cooked ground pork patties containing 10% or 20% fat treated with perforation. Perforation treatment to patties with 10% fat resulted in higher scores (more tan, $p < 0.05$) on surface color than the control except for S4N3 which had similar ratings ($p > 0.05$) to the control. Among the treated samples, S8N6 patties rated higher scores ($p < 0.05$) than other perforated patties which showed similar ($p > 0.05$) to one another. In the case of 20% fat patties, however, perforated patties were not different ($p > 0.05$) in surface color from the control. In addition, the panel found no differences ($p > 0.05$) in surface color between 10% fat and 20% fat patties except S4N6 patties which had higher scores ($p < 0.05$) in patties with 10% fat than those with 20% fat. With the exception of S4N6 patties at both levels of fat, perforation treatment resulted in having higher internal color scores ($p < 0.05$) in 10% fat patties or lower scores ($p < 0.05$) in 20% fat patties compared to the control. In degree of air pockets, patties produced with 10% fat rated similar scores ($p > 0.05$) than the control, except S8N3 patties which showed significantly more air pockets than the control, S4N6, and S8N6 samples. However, when patties were made with 20% fat, no differences ($p > 0.05$) in air pocket were found between perforated patties and the control.

IV. CONCLUSION

Although cooking rate was affected by hole size or number, perforation treatments had very limited effects on the product quality properties of cooked ground pork patties produced with 10% fat and 20% fat. An increase of fat levels resulted in a less cooking loss and a lower hardness, but more changes of patty thickness during cooking. The results suggest that application of perforation processing to ground patties would be useful means to save cooking time without any detrimental effects on quality characteristics.

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Table 1. Cooking properties of cooked ground pork patties containing 10% or 20% fat with perforation treatments

	Cooking loss (%)		Reduction in patty diameter (%)		Reduction in patty thickness (%)	
Treatments[1]	10% fat	20% fat	10% fat	20% fat	10% fat	20% fat
Control	24.50^{ax}	21.73^{ax}	11.49^{ax}	11.59^{cx}	16.96^{ay}	28.28^{ax}
S4N3	24.60^{ax}	20.09^{ay}	11.54^{ay}	13.05^{ax}	15.08^{ay}	23.54^{bcx}
S4N6	23.49^{ax}	20.35^{ay}	11.65^{ax}	12.33^{abcx}	15.10^{ay}	26.36^{abx}
S8N3	24.07^{ax}	21.16^{ax}	11.57^{ax}	11.70^{bcx}	15.54^{ay}	24.02^{bcx}
S8N6	26.02^{ax}	20.99^{ay}	11.61^{ay}	12.47^{abx}	15.81^{ay}	22.13^{cx}
SEM	0.98	0.98	0.27	0.27	1.30	1.30

[1] Treatments: Control (no-hole), S4N3 (three 4-mm holes), S4N6 (six 4-mm holes), S8N3 (three 8-mm holes), and S8N6 (six 8-mm holes).
[a-c] Means within a column with unlike superscript letters are different ($p < 0.05$).
[x, y] Means within a row with unlike superscript letters are different ($p < 0.05$).

Table 2. Textural properties of cooked ground pork patties containing 10% or 20% fat with perforation treatments

	Hardness (N)		Springiness		Cohesiveness	
Treatments[1]	10% fat	20% fat	10% fat	20% fat	10% fat	20% fat
Control	9.77^{ax}	4.92^{aby}	0.84^{ax}	0.85^{ax}	0.51^{ax}	0.44^{aby}
S4N3	9.46^{ax}	4.42^{by}	0.85^{ax}	0.83^{ax}	0.49^{ax}	0.47^{ax}
S4N6	8.91^{ax}	6.20^{ay}	0.86^{ax}	0.84^{ax}	0.50^{ax}	0.43^{aby}
S8N3	9.52^{ax}	5.71^{aby}	0.87^{ax}	0.86^{ax}	0.47^{ax}	0.41^{bx}
S8N6	9.97^{ax}	5.58^{aby}	0.82^{ax}	0.84^{ax}	0.50^{ax}	0.46^{abx}
SEM	0.48	0.48	0.02	0.02	0.02	0.02

[1] Treatments: Control (no-hole), S4N3 (three 4-mm holes), S4N6 (six 4-mm holes), S8N3 (three 8-mm holes), and S8N6 (six 8-mm holes).
[a, b] Means within a column with unlike superscript letters are different ($p < 0.05$).
[x, y] Means within a row with unlike superscript letters are different ($p < 0.05$).

Table 3. The surface color of cooked ground pork patties containing 10% or 20% fat with perforation treatments

	CIE L*		CIE a*		CIE b*	
Treatments[1]	10% fat	20% fat	10% fat	20% fat	10% fat	20% fat
Control	63.84^{ax}	58.14^{ay}	7.06^{ax}	7.24^{ax}	13.30^{ax}	12.64^{ax}
S4N3	57.86^{abx}	57.31^{ax}	7.22^{ax}	7.81^{ax}	13.21^{ax}	13.11^{ax}
S4N6	57.60^{bx}	57.30^{ax}	7.18^{ax}	7.45^{ax}	13.51^{ax}	13.34^{ax}
S8N3	59.45^{abx}	56.53^{ax}	7.33^{ax}	7.63^{ax}	13.58^{ax}	13.35^{ax}
S8N6	57.03^{bx}	57.05^{ax}	7.59^{ax}	7.23^{ax}	13.25^{ax}	13.33^{ax}
SEM	1.51	1.51	0.35	0.35	0.36	0.36

[1] Treatments: Control (no-hole), S4N3 (three 4-mm holes), S4N6 (six 4-mm holes), S8N3 (three 8-mm holes), and S8N6 (six 8-mm holes).
[a, b] Means within a column with unlike superscript letters are different ($p < 0.05$).
[x, y] Means within a row with unlike superscript letters are different ($p < 0.05$).

Table 4. Visual color attributes[1] of cooked ground pork patties containing 10% or 20% fat with perforation treatments

	Surface color		Internal color		Amount of air pockets	
Treatments[2]	10% fat	20% fat	10% fat	20% fat	10% fat	20% fat
Control	6.00^{cx}	6.06^{abx}	5.44^{by}	6.60^{ax}	4.44^{bx}	4.28^{ax}
S4N3	6.44^{bcx}	7.06^{ax}	6.56^{ax}	5.44^{bcy}	5.22^{abx}	4.45^{ax}
S4N6	6.78^{bx}	5.89^{by}	5.44^{bx}	5.94^{abx}	4.44^{bx}	5.28^{ax}
S8N3	6.89^{bx}	6.56^{abx}	6.44^{ax}	5.27^{bcy}	6.00^{ax}	4.45^{ay}
S8N6	7.55^{ax}	7.06^{ax}	6.67^{ax}	4.77^{cy}	4.56^{bx}	4.12^{ax}
SEM	0.26	0.26	0.31	0.31	0.57	0.57

[1] Scores based on 8 point scale, in which 1 = grayish pink and none, and 8 = tanned white and extremely numerous.
[2] Treatments: Control (no-hole), S4N3 (three 4-mm holes), S4N6 (six 4-mm holes), S8N3 (three 8-mm holes), and S8N6 (six 8-mm holes).
[a-c] Means within a column with unlike superscript letters are different ($p < 0.05$).
[x, y] Means within a row with unlike superscript letters are different ($p < 0.05$).