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The Relationship between Fat Level and Quality Properties of Ground Pork Patties Cooked by Microwave Energy

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전자레인지 가열시 분쇄 돈육 패티의 지방함량과 가열특성과의 상관관계에 관한 연구

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Abstract

This study was carried out to elucidate the relationship between different fat levels (0%, 5%, 10%, 15%, 20%, and 25%) and the quality of ground pork patties cooked to reach an internal temperature of 75°C in a microwave oven. The relationship between fat level and cooking rate of pork patties cooked by microwave energy was highly significant (R^2=0.72), and had a low determination coefficient (R^2=0.55). The relationship between fat level and total cooking loss of pork patties cooked by microwave energy was also very significant, with a high correlation coefficient of R^2=0.89. The correlation coefficient between fat level and cooking drip loss of patties cooked by microwave energy was 0.92, which was highly significant. Although the correlation coefficient between fat level and evaporation loss had a negative value (R^2=-0.63), there was a highly significant relationship between fat level and shear force of pork patties cooked by microwave energy.

Key words : microwave cooking, fat level, pork patties, cooking properties

Introduction

Microwave ovens for use at home have been on the market for more than two decades, and the recent increase in the use of microwave ovens world-wide has been dramatic. The saturation level of household microwave ovens in Europe, for example in the U.K and other Northern European countries, is more than 80%, and the saturation level in the U.S., Japan, and Australia is already over 100% (Ohlsson and Bengtsson, 2001). Microwave ovens have provided obvious benefits in terms of speed and convenience. On the other hand, the full potential of microwave heating is far from being realized because of its disadvantages, such as non-uniformity of heating, edge overheating, soggy texture, and lack of browning (Ohlsson and Risman, 1978; Ryynanen *et al.*, 2004; Datta *et al.*, 2005). In addition, the microwave cooking produces the lowest sensory juiciness rating compared to other methods (Risman, 1998). The main problems associated with microwave heating are caused by oven design (Schiffmann, 1992), and the geometrical shape of the food being heated (Ohlsson and Risman, 1978). The quality of microwave-heated food is also influenced by unexpected temperature profiles, excessive heating rates, and superheating (Berry, 1996).

Many factors, such as composition, cooking methods, and physical properties influence the product quality in ground meat patties during cooking (Troutt *et al.*, 1992; Ikediala *et*

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al., 1996; Serdaroglu and Degirmencioglu, 2004). In particular, it is well documented that the amount of fat in ground meat products plays an important role in the quality of the food product (Serdaroglu and Degirmencioglu, 2004; Colmenero, 2000). Fat is an essential nutrient for the maintenance of life and normal body functions, and also plays a major role in sensory characteristics such as flavor, juiciness, and texture of the food (Egbert *et al.*, 1991; Jeong *et al.*, 2004).

Numerous studies have evaluated the effect of fat levels on the sensory and physicochemical properties of ground meat products (Hoelscher *et al.*, 1987; Miller *et al.*, 1987; Colmenero, 2000; Kirchner *et al.*, 2000). Fat levels and cooking methods of patties are the most important factors, and influence the quality and safety of cooked patties (Cannell *et al.*, 1989; Gujral *et al.*, 2002). According to Gujral *et al.* (2002), as fat levels decreased in beef patties, tenderness, juiciness, and flavor ratings decreased and shear force increased. Reduction of fat in ground beef patties causes loss of palatability and product yield, especially when fat is reduced to 5-10% (Berry, 1992; Serdaroglu and Degirmencioglu, 2004). Berry (1992; 1994) found that longer cooking times were necessary to achieve similar color in cooked patties as fat was reduced in formulations. Depending on cooking methods, patties are often overcooked, leading to deterioration in textural quality. Berry and Leddy (1984) have reported for beef patties that microwave cooking produced patties with the least amount of fat and calories compared to other cooking methods. They also found that microwave cooking reduced fat retention in beef patties. Similarly, Kirchner *et al.* (2000) reported that microwaved patties tend to have less fat than patties from the other cooking methods. Also, Jeong *et al.* (2004) found that as fat levels of microwaved ground pork patties increased, total cooking loss, drip loss, and evaporation loss increased, while conversely, cooking time and shear force decreased.

In this way it is important to understand the interrelationships between these factors on fat content because of their relationship to the ultimate quality of the cooked patties. This study was carried out to elucidate the relationship between fat levels and the quality characteristics of ground pork patties cooked to reach 75°C in a microwave oven, and to provide a method for the evaluation of pork patties

Materials and Methods

Preparation of patties

Fresh pork hams were purchased from a local market at 48 hr post mortem. Pork back fat was also collected (The melting point is 35.5°C). All subcutaneous and intermuscular fat and visible connective tissue were removed from the fresh ham muscles. Lean muscles were initially ground through a 13 mm plate and the pork back fat was ground through an 8 mm plate. The fat was added to the lean meat to create patties with fat levels of 5%, 10%, 15%, 20%, and 25% (Table 1). The mixtures from each batch were mixed by hand for 3 min and twice ground to through a 3 mm plate using meat grinder (PM-70, Spain). After grinding, 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.

Table 1. Formulation of ground pork patties at different added fat levels

Items	Treatments					
Added pork fat level (%)	0	5	10	15	20	25
Pork lean meat (%)[1)]	100	95	90	85	80	75
Total (%)	100	100	100	100	100	100

[1)] The fat content in pork lean meat was 5.1±0.2%.

Microwave cooking procedure

Samples were cooked in a household-type microwave oven (Model RE-M400, Samsung Electronics Co., Korea) with full power (700 W) operating at 2450 MHz. Patties from all fat levels were held at 1°C for 24-36 hr before cooking. Patties were cooked on microwave-safe plastic containers (uncovered) containing a plastic rack which allowed drips to escape from the underside. Each patty, placed in the center of the oven, was cooked 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 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 length of cooking time needed to reach the designated internal temperature. The heating times necessary for each type of patty were: 5% fat = 103 sec; 10% fat = 100 sec; 15% fat = 96 sec; 20% fat = 93 sec; 25% fat = 86 sec. 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. After the temperature was achieved, the container including the patty and then the patty alone were immediately weighed to determine cooking loss.

Cooking rate measurements

The internal temperature of patties was measured for twenty patties per fat level before and after cooking. The cooking rates were measured as follows:

Cooking rate (°C/min) =

$$\frac{\text{Final internal temperature} - \text{Initial internal temperature}}{\text{Cooking time}} \times 100$$

Total cooking loss, cooking drip loss, and evaporation loss

Total cooking loss, cooking drip loss, and evaporation loss were determined for thirty patties per fat and water level. Total cooking loss were determined by weight differences of patties before and after cooking, and the term "cooking drip loss" designated weight loss of drips dropped only under container after microwave cooking. Also, evaporation loss of water in patties was calculated by difference between total cooking loss and cooking drip loss.

Total cooking loss (%)
= (raw weight – cooked weight of patties)/raw weight × 100
Cooking drip loss (%)
= drip weight after cooking/raw weight × 100
Evaporation loss (%)
= total cooking loss (%) – cooking drip loss (%)

Shear force measurements

Ten patties per fat level were cooked according to the procedures previously described, and then equilibrated to room temperature for 1 hr before sampling. Each patty was cut with a knife into 50 mm (L) × 25 mm (W) × 10 mm (D) 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., England). 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. The data were then converted into kg.

Statistical analysis

Data were analyzed in a one-way analysis of variance through the analysis of variance (ANOVA) procedure of the SAS statistical package (SAS Institute Inc., 1999). When F-values were significant, differences between mean values were determined using Duncan's multiple range test with α =0.05%. The procedure CORR of the SAS package was used to calculate correlations between fat level and cooking properties of ground pork patties cooked by microwave energy.

Results and Discussion

Correlations between fat level and cooking rate

According to Fakhouri and Ramaswamy (1993), temperature uniformity in cooking food was dependent on product composition, such that higher fat content improved the product heating rate as well as temperature uniformity. The relationship between fat level and cooking rate of ground pork patties cooked by microwave energy is presented in Fig. 1. As fat levels increased, cooking time decreased and cooking rate increased. This result was consistent with previous studies (Troutt *et al.*, 1992; Liu and Berry, 1996; Jeong *et al.*, 2004). They reported that low-fat patties required longer cooking times than those with high-fat. On the other hand, Cofrades *et al.* (1997) demonstrated that the effect of cooking rate on meat batter was not clearly dependent on fat content. The relationship between fat level and cooking rate of ground pork patties cooked by microwave energy was highly significant (p<0.001) and showed a non-linear regression. The correlation coefficient between the two measurements had a high positive value (r=0.72) (Table 2).

Correlations between fat level and total cooking loss

Fig. 2 shows the relationship between fat level and total cooking loss of ground pork patties cooked by microwave energy. Total cooking loss increased with increasing fat levels in the patties (p<0.001). This result was similar to results for ground chicken product (Young *et al.*, 1991), ground

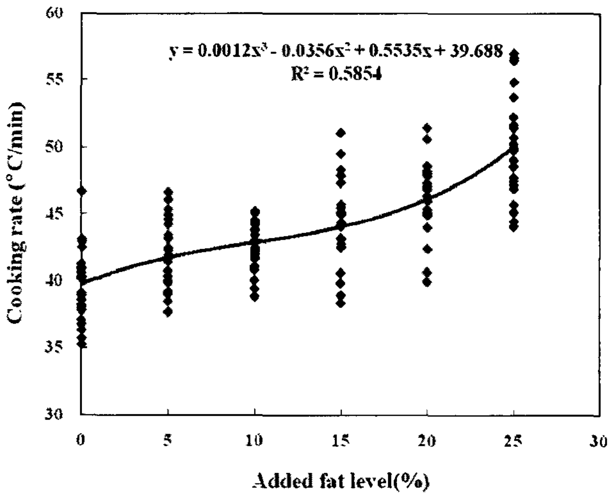

Fig. 1. The relationship between fat level and cooking rate of ground pork patties cooked by microwave energy. x=fat level, y=cooking rate, R^2=determination coefficient.

Table 2. Coefficients of correlation among measurements of ground pork patties with different added fat levels cooked by microwave energy

Measurements	Cooking rate	Total cooking loss	Cooking drip loss	Evaporation loss	Shear force
Fat level	0.72***	0.89***	0.92***	-0.63***	-0.86***
Cooking rate		0.64***	0.65***	-0.42***	-0.60***
Total cooking loss			0.95***	-0.51***	-0.93***
Cooking drip loss				-0.74***	-0.90***
Evaporation loss					0.53***

*** Highly significant statistically at p<0.001

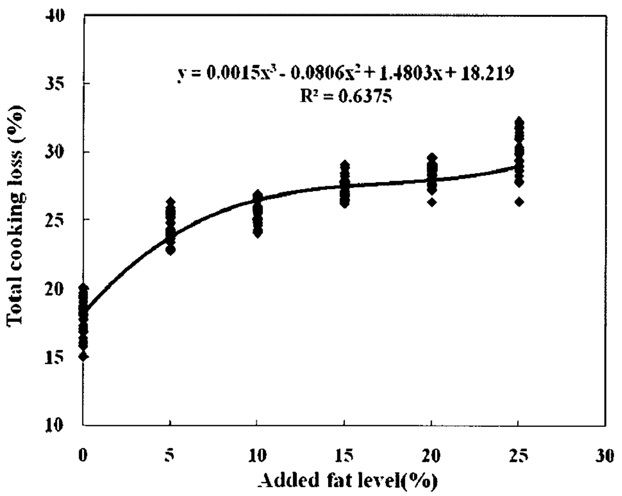

Fig. 2. The relationship between fat level and total cooking loss of ground pork patties cooked by microwave energy. x=fat level, y=total cooking loss, R^2=determination coefficient.

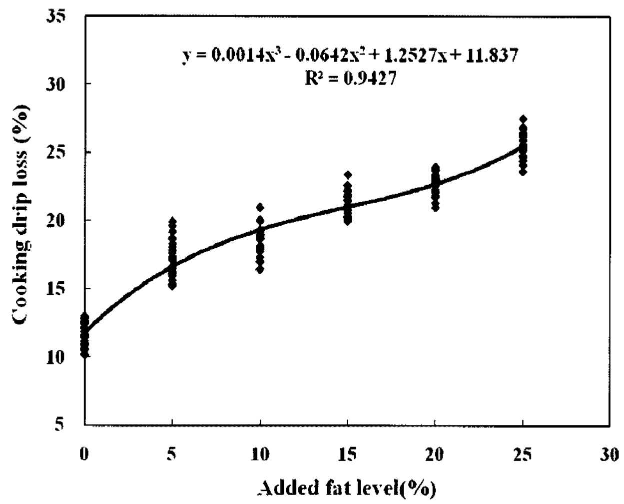

Fig. 3. The relationship between fat level and cooking drip loss of ground pork patties cooked by microwave energy. x=fat level, y=cooking drip loss, R^2=determination coefficient.

pork product (Binger and Berry, 1997), and ground beef product (Berry and Leddy, 1984). Recently, Jeong *et al.* (2004) reported that total cooking loss was the greatest for patties with 25% fat and the lowest for those with 5% fat. Love and Prusa (1992) found that increasing levels of fat in beef crumbles (10-30%) reduced cooking yields. The relationship between fat level and total cooking loss of ground pork patties cooked by microwave energy showed a non-linear regression, and the determination coefficient was R^2=0.9178 (Fig. 2). The correlation coefficient between the two measurements was a very high positive value (r=0.89). Similarly, Hoelscher *et al.* (1987) found that cooking losses of the patties were related to fat levels.

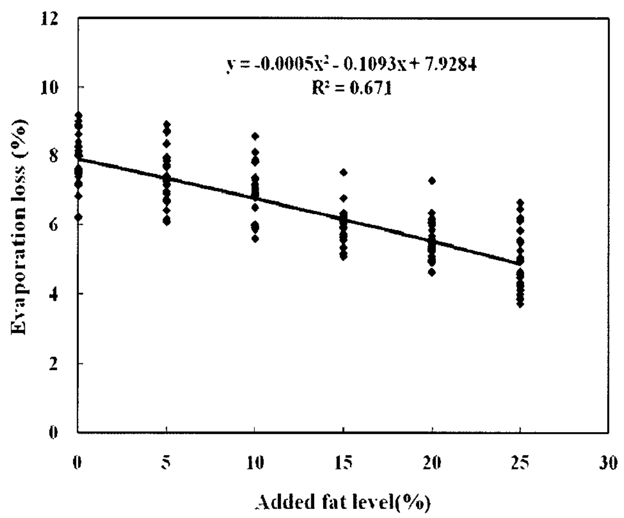

Fig. 4. The relationship between fat level and evaporation loss of ground pork patties cooked by microwave energy. x=fat level, y=evaporation loss, R^2=determination coefficient.

Correlations between fat level and cooking drip loss, evaporation loss

The relationships between fat level, cooking drip loss and evaporation loss of ground pork patties cooked by microwave energy are presented in Fig. 3 and 4. As the fat level increased, cooking drip loss during cooking also increased. But evaporation loss was lower for high-fat patties than for those with low-fat. The drip loss during cooking was considered as evaporation loss and it was related to the cooking time, and cooking temperature (Troutt *et al.*, 1992). According to Cross *et al.* (1980), the patty with more fat only appeared to lose more weight during cooking because the liquid fat remained in the pan after cooking, whereas drip loss was decreased, because most of water during cooking in the low-fat patty was evaporated. Similarly, Kregel *et al.* (1986) reported that cooking drip loss and total cooking loss in ground beef patties during cooking increased as fat level increased but evaporation loss decreased. The correlation coefficient between fat level and cooking drip loss of ground pork patties cooked by microwave energy was r=0.92 (Table 2), which was highly significant (p<0.001). But the correlation coefficient between fat level and evaporation loss had a lower negative value (r=-0.63, p<0.001) (Table 2). The relationship between fat level and cooking drip loss of ground pork patties cooked by microwave energy showed a non-linear regression, and a determination coefficient that was very high R^2=0.8986 (Fig. 3). The relationship between fat level and evaporation loss showed a non-linear regression, and the determination coefficient was low (R^2=0.3929, Fig. 4).

Correlations between fat level and shear force

Huffman and Egbert (1990) reported that as fat level decreased in beef patties, tenderness, juiciness and flavor ratings decreased and shear force increased. As fat level of ground pork patties increased, shear force during cooking decreased (Fig. 5). This result is similar to those of previous studies (Troutt *et al.*, 1992; Jeong *et al.*, 2004). They observed that shear force values decreased significantly with an increase in fat level, and Lyon *et al.* (1980) reported also that hardness increased with fat level in chicken patties. The correlation coefficient between the two measurements was a very high negative value (r=-0.86) (Table 2). The relationship between fat level and shear force of ground pork patties cooked by microwave was highly significant (p<0.001) and showed a non-linear regression (R^2=0.954). This result was similar to that of Ju and Mittal (2000), which indicated that fat level was negatively correlated with textural properties. They suggested that this may result in lower energy required to shear through a high-fat patty than a low fat patty.

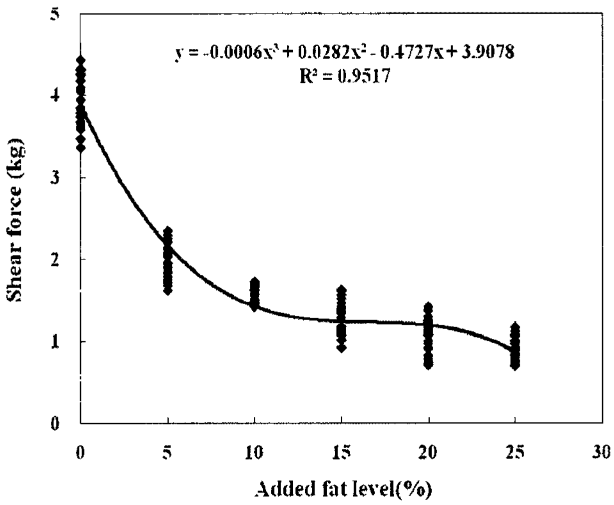

Fig. 5. The relationship between fat level and shear force of ground pork patties cooked by microwave energy. x=fat level, y=shear force, R^2=determination coefficient.

Correlations between cooking properties

Correlations between cooking properties of ground pork patties at different added fat levels are presented in Table 2. The cooking rate was positively correlated with total cooking loss (r=0.64, p<0.001) and cooking drip loss (r=0.65, p<0.001), but negatively correlated with evaporation loss (r=-0.42, p<0.001) and shear force (r=-0.06, p<0.001). This result is similar to several previous studies. Ikediala *et al.* (1996) reported that cooking loss was only related to cooking time and temperature, and Cofrades *et al.* (1997) found that cooking rate affects the texture of frankfurters regardless of fat content. Total cooking loss was positively correlated with cooking drip loss due to loss of water and fat during cooking at high temperature (r=0.95, p<0.001). Conversely, it correlated negatively with evaporation loss (r=-0.51, p<0.001) and shear force (r=-0.93, p<0.001). Similar to total cooking loss, cooking drip loss was negatively correlated with evaporation loss (r=-0.74, p<0.001). Also, the correlation coefficient with shear force was a very significant negative value (r=-0.90, p<0.001). According to Kregel *et al.* (1986), as fat level increased, cooking drip loss was negatively correlated with evaporation loss, but correlated positively with total cooking loss. These results are in agreement with the current study. The correlation coefficient between evaporation loss and shear force was a significantly positive value (r=0.53, p<0.001).

In brief, it can be concluded that the effects of fat level were very significantly and highly correlated with cooking properties of ground pork patties cooked by microwave. Fat level correlated positively with cooking rate, total cooking loss, and cooking drip loss. On the other hand, fat level correlated negatively with evaporation loss and shear force. To improve the quality characteristics of ground pork patties cooked by microwave energy, more studies of the fat level, and the addition of other ingredients in ground meat patties are necessary.

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