PE4.53 Effects of Final Internal Temperature and Reheating Methods on the Color Characteristics of Ground Pork Patties 186.00

Ji-Hun Choi (1) thuny00@naver.com, Jong-Youn Jeong(2), Jin-Man Kim 3, Chi-Ho Lee 1 Sang-Gi Min 1 Hae-Kyung Chung 4 Ju-Woon Lee 5 Cheon-Jei Kim 1

(1)Konkuk University

(2)University of Wisconsin

(3)Lotte R&D center

(4)Hoseo University Korea Atomic Energy Research Institute

***Abstract*— The purpose of this study was to evaluate the effects of reheating methods and internal temperature on color characteristics of ground pork patties. The compositions about two treatment are as follows; T1 (80% pork lean meat, 20% pork back fat, 1.5% NaCl) and T2 (same as T1 plus 0.3% phosphate). All patties were cooked by electric grill and reheating of cooked patties was conducted to convective oven (CO) and microwave oven (MO). The final internal temperatures for reheating were selected to 55, 65, and 74°C. The final internal temperature were not affected by surface color, but L^*, b^* values, hue angle, S-chroma of internal color decreased, and a^* value increased. There were no significant differences according to reheating methods. The addition of phosphate were decreased to L^*, b^* value, hue angle, S-chroma, increased to a^* value in surface and internal color. Myoglobin denaturation increased with the increase of final internal temperature, and was significantly low by the addition of phosphate and microwave oven reheating. The final internal temperatures and reheating methods did not significantly affect visual color. Therefore, the author recommends that the reheating internal temperature should be reheated between 65 and 74°C.**

J. H. Choi is with Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 143-701, Korea (e-mail: thuny00@naver.com).

C. J. Kim, C. H. Lee, S. G. Min are with Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 143-701, Korea (e-mail: kimcj@konkuk.ac.kr).

J. Y. Jeong is with the Department of Animal Science, University of Wisconsin, Madison, WI 53706, United States (e-mail: nexoxen@naver.com).

J. M. Kim is with Lotte R&D center, Seoul, 150-104, Korea (e-mail: alibaba@nate.com)

H. K. Chung is with the Department of Food Science and Nutrition, Hoseo University, Asan 336-795, Korea (e-mail: hkchung@office.hoseo.ac.kr).

J. W. Lee is with the Advanced Radiation Technology Institute, Korea Atomic Energy Research Institute, Jeongeup 580-185, Korea (e-mail: sjwlee@kaeri.re.kr).

***Index Terms*— Color characteristics, final internal temperature, ground pork, reheating method**

I. INTRODUCTION

The internal temperature of meat and meat product corresponds to “medium” according to the Color Guide in USA [1]. This guide has six pictures of beef steaks labeled as: 55°C-very rare, 60°C-rare, 63°C-medium rare, 71°C-medium, 77°C-well done and 82°C-well well done. Consumers have been advised to cook patties until no pink color remains in the center and juices run clear [2].

Lyon *et al*. [3] and Bowers *et al*. [4]reported that sensory color scores were more closely related to increase final internal temperature and visual color changes occurred between 55 and 65°C, between 65 and 75°C, and between 75 and 80°C. The color changes of cooked products are caused by additives such as salt and phosphate, and cooking condition such as cooking temperature and time [5]. In order to minimize the color change of meat products by reheating, it is necessary to make a basic study on adequate reheating temperature and time for various cooking methods such as conventional and microwave cooking. The purpose of this study, therefore, was to evaluate the effects of reheating methods and internal temperature on color characteristics of ground pork patties.

II. MATERIALS AND METHODS

A. Preparation and cooking of patties

Fresh pork (M. *biceps femoris*, M. *semitendinosus*, and M. *semimembranosus*) were purchased from a pilot plant of the Dept. Food Science & Biotechnology of Animal Resources, KonKuk University (Seoul, Korea) at 48 h postmortem. Pork back fat was also collected. All subcutaneous and intermuscular fat and visible connective tissue were removed from the muscles. Lean muscles were initially ground through Ø-13 mm plate and the pork back fat was ground through Ø-8 mm plate using a meat grinder. The compositions of two treatments were as follows; T1 (80% pork lean meat, 20% pork back fat, 1.5% salt) and T2 (same as T1 plus 0.3% phosphate). The mixtures from each batch were mixed for 30 min at 4°C using a meat mixer (RM-90, Mainca, Barcelona, Spain). The patty was formed into 120±1 g weight,

100 mm diameter, and 15 mm thickness using patty presses and then stored at 4°C.

Patties were cooked on a preheated electric grill (CG20, Hobart, OH, USA) at a grill surface temperature of 150°C.The patties were cooked for 3 min on one side and for 3 min on the opposite side, and thereafter flipped over every 2 min until the targeted center temperature reached to 76.5°C using a digital thermometer.

B. Reheating methods

The reheating final temperatures were reheated until the core temperatures of patties reached to 55, 65, or 74°C, respectively (Hunt *et al*., 1999). The samples were reheated using either a CO or a MO. For CO reheating, patties were reheated in a CO (OES 6.06, Convotherm GmbH, Eglfing, Germany) preheated to 135°C for 5 min. Each patty was placed in the center of a shelf in oven, until the targeted core temperature was reached. The core temperature of patties was monitored with a digital thermometer (Tes-1305, Tes Electrical Corp., Taipei, Taiwan) equipped with a data logger by inserting an iron constantan thermocouple. For the MO reheating, patties were cooked in a household-type MO (NN-S963/S763, Panasonic Inc., Ontario, Canada) with medium-high power (750 W). Each patty was placed in the core of the oven on a microwave-safe plastic container with a plastic rack (approximately 8-mm from the bottom of the container), which allowed the cooking drips to escape from the underside, until the targeted core temperature reached The core temperature of patties was monitored using a fiber optic system (Optical Slip Ring system, Fiso Technologies, Quebec, Canada).

C. Methods

For instrumental color measurements, the cooked and reheated patties (6 patties per each treatment) were cut just off the center (horizontal to the patty flat surface) and color values of the surface and internal cut sides were determined. Instrumental color measurements were taken with a colorimeter (Chroma meter CR-210, Minolta, Osaka, Japan; illuminate C, calibrated with white standard plate L^*=97.83, a^*=-0.43, b^*=+1.98). Hue angle (*H*) and saturation index (*S*) were calculated [6]. Samples were analyzed for myoglobin denaturation and percent metmyoglobin. Myoglobin and metmyoglobin were extracted by a modification of procedures by Warriss [7]. The myoglobin concentration and percent metmyoglobin were calculated using Kryzwicki [8]. An analysis of variance were performed on all the variables measured using the General Linear Model (GLM) procedure of the SAS statistical package [9]. The Duncan's multiple range test (p<0.05) was used to determine difference between treatment means.

III. RESULTS AND DISCUSSION

The effect of internal temperature and reheating methods on instrumental color properties in reheated pork patties are presented in Table 1 and 2. Regarding surface color, the presence of phosphate in patties reheated by the convective oven decreased the CIE-L^* value and hue angle, while increasing in a^* value (P<0.05). Moreover, their parameters were remarkably different at 55°C compared with at 65 and 74°C in the phosphate treatments (P<0.05). But color parameters in patties reheated using the microwave oven were significantly different relative to their final internal temperature (P>0.05). They were also nearly affected by the reheating method. The phosphate-treated patties had lower L^* value (darker), b^* value, and hue angle (more brown) and higher a^* value (redder) than the untreated patties (P<0.05).

Many consumers use the internal cooked appearance of patties to evaluate doneness. As internal temperature increased, the phosphate-untreated patties decreased in L^*, b^* value, hue angle, S-chroma (darker, more intense brown) and increased in a^* value (P<0.05). But in the phosphate-treated patties the color parameters were not affected by internal temperature (P>0.05). Also, the phosphate treatments were significantly lower L^*, b^* value, hue angle, and S-chroma (darker, more intense red), higher a^* value (redder) than non-phosphate treatments (P<0.05). L^*, a^* value and hue angle were affected by reheating methods in high internal temperature (74°C). The result of this study is similar to the finding of Hague [10], who showed that L^*, b^* values, and hue angle increased as endpoint temperature increased.

Table 1. The effect of internal temperature and reheating methods on surface color in reheated pork patties

Traits	Reheating methods[1)]	Treatments without phosphate		
		55°C	65°C	74°C
Surface color				
CIE-L*	CO	60.77^{A}	61.18^{A}	61.07^{AX}
	MO	59.87^{A}	59.78^{A}	58.70^{ABY}
CIE-a*	CO	3.11^{BC}	2.97^{C}	3.19^{BC}
	MO	2.89^{C}	2.90^{C}	3.05^{BC}
CIE-b*	CO	14.90^{AB}	15.25^{AB}	15.79^{A}
	MO	14.50	14.42	14.15
Hue angle	CO	78.16^{A}	78.96^{A}	78.55^{A}
	MO	78.73^{A}	78.58^{A}	77.82^{AB}
S-chroma	CO	15.22^{AB}	15.54^{AB}	16.12^{A}
	MO	14.80	14.72	14.50
Traits	Reheating methods[1)]	Treatments with phosphate		
		55°C	65°C	74°C
Surface color				
CIE-L*	CO	58.50^{BX}	58.50^{BX}	58.50^{BX}
	MO	56.91^{BCY}	56.91^{BCY}	56.91^{BCY}
CIE-a*	CO	3.58^{B}	3.58^{B}	3.58^{B}
	MO	3.55^{AB}	3.55^{AB}	3.55^{AB}
CIE-b*	CO	14.50^{B}	14.50^{B}	14.50^{B}
	MO	13.94	13.94	13.94
Hue angle	CO	76.12^{B}	76.12^{B}	76.12^{B}
	MO	75.64^{BC}	75.64^{BC}	75.64^{BC}
S-chroma	CO	14.94^{B}	14.94^{B}	14.94^{B}
	MO	14.41	14.41	14.41

All values are mean. [1)] CO: convective oven; MO: microwave oven. [A-C] Means values with different superscripts within a same row are significantly different (P<0.05). [X, Y] Means values with different superscripts within a same column are significantly different (P<0.05)

Table 2. The effect of internal temperature and reheating methods on internal color in reheated pork patties

Traits	Reheating methods[1)]	Treatments without phosphate		
		55°C	65°C	74°C
Internal color				
CIE-L*	CO	66.26^{A}	66.637^{A}	65.06^{BX}
	MO	66.11^{A}	65.29^{B}	63.82^{CY}
CIE-a*	CO	4.98^{C}	3.68^{D}	6.09^{BX}
	MO	4.14^{C}	4.25^{C}	4.98^{BY}
CIE-b*	CO	9.20^{B}	10.49^{A}	7.90^{C}
	MO	10.08^{A}	9.62^{A}	8.34^{B}
Hue angle	CO	60.68^{B}	70.56^{A}	52.35^{C}
	MO	67.38^{A}	66.00^{A}	59.15^{B}
S-chroma	CO	10.71^{A}	11.14^{A}	9.99^{B}
	MO	10.93^{A}	10.55^{AB}	9.76^{C}
Traits	Reheating methods[1)]	Treatments with phosphate		
		55°C	65°C	74°C
Internal color				
CIE-L*	CO	62.67^{C}	62.26^{C}	62.44^{CX}
	MO	62.36^{D}	61.80^{DE}	61.45^{EY}
CIE-a*	CO	7.82^{A}	7.51^{A}	7.53^{AX}
	MO	6.43^{A}	6.41^{A}	5.64^{BY}
CIE-b*	CO	6.42^{D}	6.76^{D}	6.83^{D}
	MO	7.61^{BC}	7.29^{C}	7.90^{BC}
Hue angle	CO	39.37^{DY}	42.05^{D}	42.35^{DY}
	MO	49.34^{CX}	48.56^{C}	54.38^{BCX}
S-chroma	CO	10.12^{B}	10.14^{B}	10.23^{B}
	MO	10.08^{BC}	9.79^{C}	9.73^{C}

All values are means. [1)] CO: convective oven; MO: microwave oven. [A-E] Means values with different superscripts within a same row are significantly different (P<0.05). [X, Y] Means values with different superscripts within a same column are significantly different (P<0.05)

Fig. 1 shows the change of myoglobin denaturation on reheated pork patties as a function of internal temperatures and reheating methods. As the final internal temperature increased, myoglobin denaturation of patties reheated using the convective oven increased (P<0.05). But the final internal temperature did not affect myoglobin denaturation of patties reheated using the microwave oven (P>0.05). No significant differences in myoglobin denaturation were found among reheating methods (P>0.05). Interestingly, myoglobin denaturation of patties with phosphate increased 2 times more when reheating compared to cooking. The reheating of precooked products results in lipid oxidation and pigment oxidation, thus, the color changes of cooked products are caused by additives such as salt and phosphate, and cooking conditions such as cooking temperature and time. The investigation of instrumental color properties showed that although color of patties was already fixed through cooking, the reheating method and final internal temperature achieved by reheating can change instrumental and visual color of meat products.

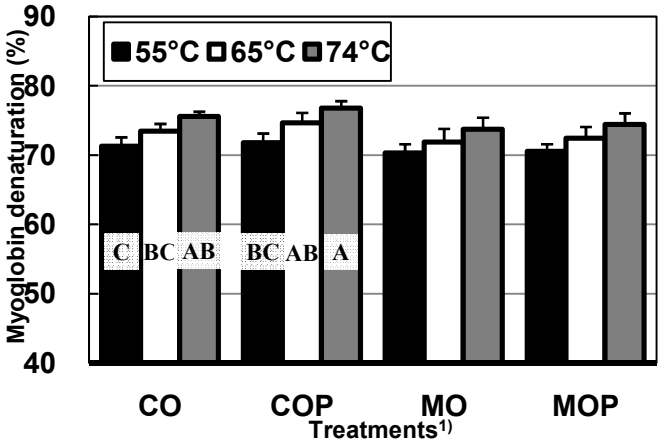

Fig. 1. Changes of myoglobin denaturation on reheated pork patties with different internal temperatures and reheating methods.

[1)] CO: treatment without phosphate reheated by convective oven; MO: treatment without phosphate reheated by microwave oven; COP: treatment with phosphate reheated by convective oven; MOP: treatment with phosphate reheated by microwave oven

A-C Means values with different letters among the treatments reheated by convective oven are significantly different (P<0.05)

The final internal temperatures did not significantly affect visual color (P>0.05, Table 3). This reason is because patties were already cooked at high temperature (76.5°C) and although there were significant differences in the instrumental color, sensory panel didn't detected significant differences between all treatments.

Table 3. The effect of internal temperature and reheating methods on sensory color in reheated pork patties

Treatments	Reheating methods[2)]	Internal temperature		
		55°C	65°C	74°C
T1[1)]	CO	7.80	8.00	7.90
	MO	7.60	7.80	7.40
T2[1)]	CO	7.90	8.00	7.95
	MO	7.65	7.80	7.70

All values are mean. [1)] T1: treatment with salt 1.5%, T2: treatment with salt 1.5% and 0.3% phosphate. [2)] CO: convective oven; MO: microwave oven.

IV. Conclusion

The reheating methods affected the myoglobin denaturation, but not the instrumental color. The addition of phosphate affected color properties of reheated patties on the outside. The final internal temperature was affected by internal color and myoglobin denaturation. Therefore, the author recommends the reheating method using the reheating final internal temperature between 65 and 74°C, the addition of phosphate, and reheating by microwave oven

Acknowledgement

This article was supported by the Brain Korean 21 (BK 21) Project from Ministry of Education and Human Resources Development, Republic of Korea.

References

[1] American Meat Science Association. (1995). Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. National Live Stock and Meat Board, Chicago, USA.

[2] USDA. (1994). A quick consumer guide to safe food handling and labels. Home Garden Bull. No. 254. FSIS, U. S. Department of Agriculture, Washington, D. C.

[3] Lyon, B. G., Greene, B. E., & Davis, C. E. (1986). Color, doneness and soluble protein characteristics of dry roasted beef *semitendinosus*. Journal of Food Science, 51, 24-26.

[4] Bowers, J. A., Craig, J. A., Kropf, D. H., & Tucker, T. J. (1987). Flavor, color, and other characteristics of beef *longissimus* muscle heated to seven internal temperatures between 55 and 85°C. Journal of Food Science, 52, 533-536

[5] Lien, R., Hunt, M. C., Anderson, S., Kropf, D. H., Loughin, T. M., Dkeman, M. E., & Velazco, J. (2002) Effects of endpoint temperature on the internal color of pork loin chops of different quality. Journal of Food Science, 67, 1007-1010.

[6] Hunter, R. S. & Harold, R. W. (1987). The measurement of appearance. (pp. 108-177). New York: John Wiley and Sons.

[7] Warris, P. D. (1979). The extraction of haem pigments form fresh meat. Journal of Food Technology, 14, 75-80.

[8] Kryzwicki, K. (1979). Assessment of relative content of myoglobin, oxymyoglobin and metmyoglobin at the surface of beef. Meat Science, 3, 1-10.

[9] SAS Institute, Inc. (1999) SAS User's Guide. Statistical Analysis Systems Institute, Cary, NC, USA.

[10] Hague, M. A, Warren, K. E., Hunt, M. C., Gropf, D. H., Kastner, C. L., Stroda, S. L., & Johnson, D. E. (1994). Endpoint temperature, internal cooked color, and expressible juice color relationships in ground beef patties. Journal of Food Science, 59, 465-470.