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Optimizing the Combination of Smoking and Boiling on Quality of Korean Traditional Boiled Loin (*M. longissimus dorsi*)

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Abstract

The combined effects of smoking and boiling on the proximate composition, technological quality traits, shear force, and sensory characteristics of the Korean traditional boiled loin were studied. Cooking loss, processing loss, and shear force were lower in the smoked/boiled samples than those in the control (without smoking treatment) ($p<0.05$). The results showed that the boiled loin samples between the control and treatment did not differ significantly in protein, fat, or ash contents, or pH values ($p>0.05$). The treated samples had higher score for overall acceptability than the control ($p<0.05$). Thus, these results show that the Korean traditional boiled loin treated with smoking for 60 min before boiling had improved physicochemical properties and sensory characteristics.

Key words: smoking, boiling, sensory properties, combination, quality characteristics

Introduction

Traditional Korean boiled pork is simmered with garlic, ginger onion, and leek and is one of the most popular foods in Korea (Kim, 1995; Moon, 2002). Boiled pork has been served at family events for a long time (Choi *et al*., 2006). Some studies have been conducted on Korean boiled pork. Chae and Kim (2010) reported that textural properties and sensory quality of boiled pork improve using different cooking methods. Choi *et al*. (2006) found that boiled pork loin using a tumbling method improved quality. Park and Kwon (1998) indicated that the sensory characteristics and tenderness of boiled beef were enhanced by adding bark. They reported that boiled beef made with 5% bark powder has decreased cooking loss and improved sensory properties. Jung *et al*. (2004) reported the effects of carcass grade and adding mugwort powder on boiled pork quality. Their results showed that water holding capacity, 2-thiobarbituric acid reactive substance values, and residual nitrite in boiled pork with added mugwort powder were lower than those of boiled

pork without added mugwort powder. However, the boiled meat had poor sensory properties; thus, it is necessary to promote consumer acceptability by improving flavor and textural attributes (Choi, 2005).

Smoking meat products is one of the most ancient food technologies which have been used for food preservation (Djinovic *et al*., 2008). In general, smoke develops in an external generator under controlled conditions of temperature and air access. Smoking methods are divided according to smoking temperature; the cold-smoking process uses 15-30°C (relative humidity: 75-85%), the hot smoking process uses 30-50°C (relative humidity: 50-70%), and the high temperature smoking process uses 50-80°C (relative humidity: 40-50%). Smoking technology uses the special effects of diverse sensory active compounds contained in smoke to aromatize meat products. These compounds are polycyclic aromatic hydrocarbons and their alkylated derivatives. Thus, smoked meat products are a significant part of the human diet because of their excellent taste, high nutritional value, and large variety of available products (Kim *et al*., 2014). Stolyhwo and Sikorski (2005) reported that smoke composition and processing conditions affect sensory quality, shelf life, and wholesomeness of the product. Several studies have been conducted on boiling methods (Chae and Kim,

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2010; Choi *et al*., 2006; Jung *et al*., 2004; Park and Kwon, 1998) and smoke treatments (Djinovic *et al*., 2008; Song *et al*., 2013; Stolyhwo and Sikorski, 2005). However, research on meat products prepared with a combination of smoking and boiling is limited.

Therefore, the objective of this study was to evaluate the effects of combined smoking and boiling on proximate composition, smoking loss, cooking loss, processing loss, pH, color, shear force, and sensory characteristics of Korean traditional boiled loin.

Materials and Methods

Preparation and processing

Fresh pork loin (*M. longissimus dorsi*) with 70.51% moisture, 4.78% fat, 16.38% protein from castrated boars [Landrace × Yorkshire × Duroc] at 5 mon old was purchased 10 from a local processor 48 h postmortem. All subcutaneous, intramuscular fat and visible connective tissue were removed from the fresh loin muscle. Five different treatments were prepared. The first sample was the control prepared by heat processing in a 100°C water bath (model 10-101, Dae Han Co, Korea) until core temperature reached 75°C for about 30 min. Then the cooked pork was cooled at 20°C. The other four samples were prepared by smoking before being boiled. The samples were smoked in a smoke chamber (Model MAXi3501, Kerres, Germany) continually at 65°C (relative humidity: 50%) for 15, 30, 60, or 90 min respectively. The smoke treatment included a smoke chamber and oak wood chips. The smoked samples were heat processed in a 100°C water bath until a 75°C core temperature was reached. Then the cooked Korean traditional boiled loin was cooled at 20°C. This procedure was performed in triplicate for each sample, and all analyses were carried out at least in triplicate for each formulation.

Proximate composition

Composition properties of the samples were determined using AOAC methods (2007). Moisture content (950.46B) was calculated by weight loss after 18 h of drying at 105°C in a drying oven (SW-90D, Sang Woo Scientific Co., Korea). Fat content (960.69) was determined by the Soxhlet method with a solvent extraction system (Soxtec Avanti 2050 Auto System, Foss Tecator AB, Sweden), and protein content (981.10) was determined by the Kjeldahl method with an automatic Kjeldahl nitrogen analyzer (Kjeltec 2300Analyzer Unit, Foss Tecator AB). The nitrogen conversion factor was 6.25. Ash content

was determined according to the AOAC method 923.93 (muffle furnace).

Purge loss

Smoking loss, cooking loss, and processing loss were determined on Korean traditional boiled loin by calculating the weight differences for pork loin before and after smoking and cooking as follows:

Smoking loss (%) = (raw weight − smoked weight) / raw weight × 100

Cooking loss (%) = (smoked weight − cooked weight) / smoked weight × 100

Processing loss (%) = smoking loss + cooking loss

pH

The pH values of sample were measured in a homogenate prepared with 5 g of sample and distilled water (20 mL) using a pH meter (Model 340, Mettler-Toledo GmbH, Switzerland). The pH meter calibrated with standard 4.00, 7.02, and 10.05 pH buffers (VWR Scientific Products) at a temperature of 20±1°C. All determinations were performed in triplicate.

Color

The color of each sample was determined using a colorimeter (Minolta Chroma meter CR-210, Minolta Ltd., Japan; illuminate C, calibrated with a white plate, L^*= +97.83, a^*=-0.43, and b^*=+1.98). Seven measurements for each sample of five replicates were obtained. CIE L^* (lightness), CIE a^* (redness), and CIE b^* (yellowness) values were recorded.

Warner-Bratzler shear force (WBSF)

The Warner-Bratzler shear force was measured at room temperature using a texture analyzer (TA-XT2*i*, Stable Micro Systems Ltd., England) according to the method of Hong *et al*. (2008). The cooked samples were cooled at room temperature for 30 min. The samples were allowed to equilibrate to room temperature. Each sample was cut with a knife into length × width: 3 × 4 cm sections and the sections were sheared in separate locations with Warner-Bratzler blade set attached to a texture analyzer. The Warner-Bratzler head moved at a crosshead speed of 200 mm/min. Data were collected and analyzed from Warner-Bratzler shear force values to obtain for the maximum force required to shear through each sample and

was then converted into kg.

Sensory evaluation

The sensory evaluations were performed in triplicate on each sample by trained sensory panelist. A selected twelve-member panel consisting of researchers from the Department of Food Sciences and Biotechnology of Animal Resources at Konkuk University in Korea was used to evaluate the cooked samples. Selection of panelists was performed according to sensory evaluation procedure (Lawless and Heymann, 1999). Each cooked sample was evaluated in terms of color, flavor, juiciness, tenderness, and overall acceptability. The cooked samples were cut into quarters (length × width: 3 × 4 cm), and served randomly to the panelists. Each sample was coded with a randomly selected 3-digit number. Sensory evaluations were performed under fluorescent lighting. Panelists were instructed to cleanse their palates with water between samples. 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 by Bergara-Almeida and da Silva (2002).

Statistical analysis

The experiments were replicated three times, and values represent the mean and standard. Analysis of variance (proximate composition, smoking loss, cooking loss, processing loss, pH, color, WBSF, and sensory evaluation) was conducted using the general linear model (GLM) procedure of the SAS statistical package (2008). Duncan's multiple range tests ($p<0.05$) was used to determine the differences among treatments.

Results and Discussion

Proximate composition

The proximate composition of the Korean traditional boiled loin treated by combined smoking and boiling is shown in Table 1. The highest moisture contents were observed in the 60 and 90 min smoke treated samples before being boiled (S60 and S90) compared to that in the other treatments ($p<0.05$). These contrasting results could be attributed due to the increased moisture content during smoking, which is caused by a hard coating that forms on the meat surface and reduces cooking loss (Table 2). Chae and Kim (2010) reported that high temperature and long cooking time produces lower moisture content in boiled pork. According to Chae (2011), the moisture content in boiled pork is influenced by cooking methods such as boiling and steaming. However, Hyon et al. (2003) reported that the effects of curing temperature and time on moisture content of cured boiled pork loin did not differ significantly among treatments. Protein, fat, and ash contents were not significantly different between the control without smoking and those of samples that were smoked ($p>0.05$).

Purge loss

Table 2 shows smoking loss, cooking loss, and processing loss in Korean traditional boiled loin treated with combined smoking and boiling. Smoking loss increased significantly by increasing smoking time ($p<0.05$). Cooking loss of the pork loin was lower for treatments treated with combined smoking and boiling than that of the control ($p<0.05$). The highest processing loss was in the control compared to that in the combined smoking and boiling treatment ($p<0.05$), but it did not differ significantly among all treatments ($p>0.05$). According to Pan and Singh (2001), cooking loss in cooked meat products increases as heating temperature increases. Chae (2011)

Table 1. Effect of smoking period on proximate composition of Korean traditional boiled loin treated with a combination of smoking and boiling (Units: %)

Parameters	Control [1]	S15	S30	S60	S90
Moisture content	62.12±0.24[B]	62.85±0.31[B]	63.38±0.48[AB]	64.57±0.70[A]	64.05±0.42[A]
Protein content	26.32±0.45	27.31±0.32	27.45±0.42	27.67±0.31	27.75±0.25
Fat content	3.21±0.14	3.17±0.13	3.16±0.12	3.19±0.14	3.18±0.11
Ash content	3.43±0.84	3.01±0.51	3.49±0.61	3.34±0.85	3.18±0.24

All values are mean±standard deviation of three replicates.
[A,B]Means within a row with different letters are significantly different ($p<0.05$).
[1]Control: pork loin without smoking before boiling, S15: pork loin treated with a combination of smoking for 15 min and boiling, S30: pork loin treated with a combination of smoking for 30 min and boiling, S60: pork loin treated with a combination of smoking for 60 min and boiling, S90: pork loin treated with a combination of smoking for 90 min and boiling.

Table 2. Effect of smoking period on purge loss of Korean traditional boiled loin treated with a combination of smoking and boiling (Units: %)

Parameters	Control [1]	S15	S30	S60	S90
Smoking loss	-	10.76±0.98[D]	12.11±0.56[C]	14.44±0.92[B]	16.03±0.89[A]
Cooking loss	34.85±4.31[A]	19.20±4.53[B]	17.03±4.61[B]	11.45±4.77[C]	12.73±5.80[C]
Processing loss	34.85±4.31[A]	29.96±4.68[B]	29.13±4.70[B]	25.88±5.50[B]	28.76±6.20[B]

All values are mean±standard deviation of three replicates.
[A-D]Means within a row with different letters are significantly different ($p < 0.05$).
[1]Control: pork loin without smoking before boiling, S15: pork loin treated with a combination of smoking for 15 min and boiling, S30: pork loin treated with a combination of smoking for 30 min and boiling, S60: pork loin treated with a combination of smoking for 60 min and boiling, S90: pork loin treated with a combination of smoking for 90 min and boiling.

Table 3. Effect of smoking period on pH of Korean traditional boiled loin treated with a combination of smoking and boiling

Parameters	Control [1]	S15	S30	S60	S90
Raw meat	5.86±0.21	5.81±0.24	5.82±0.22	5.81±0.25	5.79±0.24
After smoking	-	5.90±0.21	5.91±0.24	5.94±0.19	5.93±0.23
After boiling	6.28±0.18	6.12±0.20	6.18±0.21	6.14±0.26	6.17±0.24

All values are mean±standard deviation of three replicates.
[1]Control: pork loin without smoking before boiling, S15: pork loin treated with a combination of smoking for 15 min and boiling, S30: pork loin treated with a combination of smoking for 30 min and boiling, S60: pork loin treated with a combination of smoking for 60 min and boiling, S90: pork loin treated with a combination of smoking for 90 min and boiling.

indicated that cooking loss in boiled pork increases as the periods of boiling and steaming increase. Pöhlmann et al. (2012) found that purge loss from lightly smoked sausages was higher as a result of longer smoking time. Also, Kim et al. (2014) indicated that hot smoke processed sausages show decreased cooked yield, and the cooking loss of the smoked treatments was higher than that of the other treatments. These results seem to indicate that processing loss from smoked treatments is lower, which is affected by the smoke coating formed on the pork meat surface because the moisture contained in the meat is not released.

pH and color

The pH of Korean traditional boiled loin treated with combined smoking and boiling is shown Table 3. The pH was not significantly different between the control and the combined smoking and boiling treatment ($p > 0.05$). Smoking did not significantly influence the pH value of pork loin. However, pH of the smoke-treated samples was higher than that in before smoking, but treatments after cooking had an increased pH. These results agree with those reported by Choi et al. (2009), who found that the pH of meat products increases with heating due to the imidazolium that is unfolded and exposed and has basic activity due to high histidine content. Jeon et al. (1995) reported that pH of bacon is not affected by smoking temperature.

The statistical results indicated that the color parameters of the Korean traditional boiled loin were affected by smoking and boiling (Table 4). The CIE L^* (lightness) value of the treatments after smoking increased with an increase in smoking period ($p > 0.05$), whereas the lightness values after boiling decreased by increasing the smoking time ($p > 0.05$). The CIE a^* (redness) and the CIE b^* (yellowness) values of treatments before they were boiled tended to increase slightly by increasing the smoking period. The redness and yellowness values of samples after boiling increased as the smoking period increased. A study by Kim et al. (2014) reported increased lightness and decreased yellowness of cooked sausages treated with/without smoking. Pöhlmann et al. (2012) indicated that lightly smoked meat products are less colored than medium and intensively smoked meat products, and the lightness value of lightly smoked meat products was higher than of intensively smoked meat products. Chae and Kim (2010) reported that the instrumental color of Korean boiled pork was different based on cooking conditions.

Shear force

The effects of smoking and boiling on shear force of the Korean traditional boiled loin are shown in Fig. 1. The highest shear force was in the control, whereas the lowest shear force was in the pork loin treated with 60 or 90 min of smoking followed by boiling (S60 and S90). Chae and Kim (2010) reported that the effects of various cooking conditions on shear force of boiled pork were
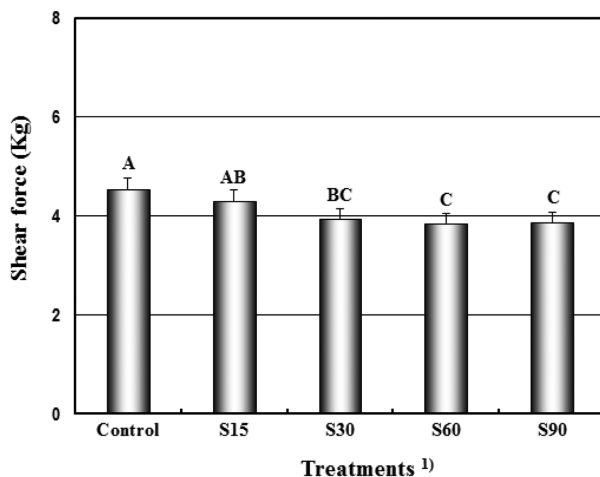
Table 4. Effect of smoking period on color values of Korean traditional boiled loin treated with a combination of smoking and boiling

	Parameters	Raw meat	After smoking	After boiling
	Control [1]	51.19±2.73	-	65.88±2.23[AB]
	S15	51.97±3.17	49.23±1.62[B]	66.39±1.84[A]
CIE L^*	S30	52.05±2.60	49.58±1.59[AB]	64.72±1.31[B]
	S60	51.56±2.62	50.00±1.66[AB]	62.15±1.21[C]
	S90	52.15±2.53	50.90±2.18[A]	59.48±1.50[D]
	Control	14.49±0.92	-	5.43±0.58[D]
	S15	14.47±1.19	13.63±1.31[B]	5.85±0.55[CD]
CIE a^*	S30	14.58±0.88	13.63±1.14[B]	6.26±0.54[C]
	S60	14.43±0.84	14.48±1.19[AB]	7.27±0.43[B]
	S90	14.33±1.04	14.84±1.53[A]	8.30±0.88[A]
	Control	3.27±1.42	-	8.14±0.67[D]
	S15	3.10±1.65	6.19±1.59[B]	10.89±1.00[C]
CIE b^*	S30	3.20±1.45	6.70±1.54[AB]	12.27±1.04[B]
	S60	3.04±1.26	7.49±2.72[AB]	13.84±0.86[A]
	S90	3.19±1.34	8.40±3.75[A]	14.03±1.00[A]

All values are mean±standard deviation of three replicates.
[A-D]Means within a column with different letters are significantly different ($p < 0.05$).
[1]Control: pork loin without smoking before boiling, S15: pork loin treated with a combination of smoking for 15 min and boiling, S30: pork loin treated with a combination of smoking for 30 min and boiling, S60: pork loin treated with a combination of smoking for 60 min and boiling, S90: pork loin treated with a combination of smoking for 90 min and boiling.

Fig. 1. Effect of smoking period on shear force of Korean traditional boiled loin treated with a combination of smoking and boiling. [A-C]Means in the treatments with different letters are significantly different ($p < 0.05$). [1]Control, pork loin without smoking before boiling, S15, pork loin treated with a combination of smoking for 15 min and boiling, S30, pork loin treated with a combination of smoking for 30 min and boiling, S60, pork loin treated with a combination of smoking for 60 min and boiling, S90, pork loin treated with a combination of smoking for 90 min and boiling.

significant. Choi et al. (2006) showed that tumbling boiled pork loin produces lower shear force than control (without tumbling treatment). According to Kim et al. (2014),

smoke processing contributes to increase hardness. Kelle et al. (2004) observed that moist-heat cooked beef steak has lower shear force than that of dry-heat cooked steak, whereas Van Oeckel et al. (1999) found that Warner-Bratzler shear force of meat samples grilled to an internal temperature of 74°C was higher than that of steaks boiled at 75°C for 50 min. Generally, tenderness is a major quality attribute of a meat product. Thus, Korean traditional boiled loin processed by boiling and smoking was the method to improve tenderness, particularly a 60 or 90 min smoking time before boiling.

Sensory evaluation

The sensory traits of the Korean traditional boiled loin treated with smoking and boiling are given in Table 5. The control samples had the lowest overall sensory trait scores ($p < 0.05$), compared to those of the combined smoking and boiling-treated samples ($p < 0.05$). These results may be due to the smoke treatment. The overall acceptability score was the highest for the combined 60 min smoking time and boiling (S60) ($p < 0.05$). These results agree with those reported by Kim et al. (2014), who found that a smoke processing treatment contributed to increase the flavor and overall acceptance satisfaction scores. Similar results were obtained by Park et al. (2010) for the influence of added smoke processing on sensory quality of shark meat. They reported that smoked meat has better taste, color, flavor, appearance, texture, and

Table 5. Effect of smoking period on sensory properties of Korean traditional boiled loin treated with a combination of smoking and boiling

Parameters	Control [1]	S15	S30	S60	S90
Color of appearance	7.64±0.67[D]	8.36±0.50[C]	8.64±0.81[BC]	8.73±0.65[AB]	8.82±0.87[A]
Color of internal	7.63±0.71[C]	8.13±0.68[B]	8.17±0.64[B]	8.29±0.69[B]	8.75±0.79[A]
Flavor	7.45±0.69[B]	8.45±0.82[A]	8.82±0.75[A]	8.82±0.60[A]	8.82±0.75[A]
Smoking flavor	2.74±0.91[C]	6.00±1.00[B]	7.39±1.03[AB]	8.17±0.83[A]	8.30±1.22[A]
Tenderness	7.92±0.83[D]	8.32±0.78[C]	8.45±0.82[BC]	9.09±0.70[A]	8.82±0.60[AB]
Juiciness	7.82±0.87[C]	8.41±0.92[B]	8.52±0.81[AB]	9.09±0.83[A]	8.69±0.80[A]
Overall acceptability	7.86±0.45[D]	8.41±0.66[C]	8.82±0.75[C]	9.27±0.65[A]	8.73±0.64[AB]

All values are mean±standard deviation of three replicates.

[A-D]Means within a row with different letters are significantly different ($p<0.05$).

[1]Control: pork loin without smoking before boiling, S15: pork loin treated with a combination of smoking for 15 min and boiling, S30: pork loin treated with a combination of smoking for 30 min and boiling, S60: pork loin treated with a combination of smoking for 60 min and boiling, S90: pork loin treated with a combination of smoking for 90 min and boiling.

overall acceptability compared to those of a control that was not smoked. Jeon *et al*. (1995) indicated that wet smoked bacon had higher overall acceptability scores than that of dry smoked bacon. Chae and Kim (2010) reported that the effects of various cooking methods on overall acceptability of boiled pork were significant. However, Montgomery *et al*. (1977) found that juiciness, tenderness, and overall acceptability was not different when pork loin was heated in a microwave or a conventional oven to an internal temperature of 63°C. According to Choi *et al*. (2006), tumbling processing of boiled pork loin results in higher sensory evaluation scores than those of no tumbling pork lion.

Conclusion

We showed that the combination of smoking and boiling had an important effect on Korean traditional boiled loin quality. Korean traditional boiled loin treated with smoking and boiling had improved processing loss, shear force, and sensory properties. The Korean traditional boiled loin treated with 60 min of smoking followed by boiling had higher overall acceptability than that of the other treatments. Therefore, these results show that pork lion combined smoking for 60 min and boiling showed the best quality characteristics.

Acknowledgements

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