EFFECTS OF SALT LEVEL AND DRYING TIME ON QUALITY OF DRY-CURED HAM: PART 2. COLOR, FATTY ACID COMPOSITIONS AND SENSORY PROPERTIES OF DRY-CURED HAM

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Abstract*—The aim of this work was to analyze the effects of salt level and drying time on color, fatty acid compositions and sensory properties of dry-cured ham. In this study, three treatments were prepared with 54 hams: High salt group (HS), 18 hams were salted with 70 g/kg salt (w/w): Middle salt group (MS), 18 hams were salted with 50 g/kg salt: Low salt group (LS), 18 hams were salted with 30 g/kg salt. Three conditions of drying time were applied such as 180 d, 270 d, 360 d. CIE L* (lightness) values of MS and LS groups were significantly ($p<0.05$) decreased as drying time increased. CIE a* (redness) values of LS group were higher than those of HS and MS groups during all drying time. When drying time increased, CIE b* (yellowness), chroma and Hue values of all treatment groups were significantly ($p<0.05$) increased. In the fatty acid compositions of all treatment groups, saturated fatty acid contents were significantly ($p<0.05$) increased, whereas unsaturated fatty acid contents were significantly ($p<0.05$) decreased as drying time increased. In the sensory evaluation, fermentation aroma scores of MS group dried during 180 days and 360 days were higher than those of MS group dried during 270 days ($p<0.05$). Hardness scores of LS group were lower than those of the other groups for all drying period ($p<0.05$). When salt addition level decreased and drying period increased, juiciness scores of dry-cured ham were more juicy ($p<0.05$). As salt addition level increased, saltiness scores of dry-curd ham were significantly ($p<0.05$) increased. Flavor intensity scores of HS and LS groups were significantly ($p<0.05$) increased as drying time increased.

***Index Terms*— color, dry cured ham, fatty acid, salt, sensory properties**

I. INTRODUCTION

Dry-curing is the common ways to keep pork in the South European countries. The traditional dry-cured hams have been produced using only pork, sea salt, fresh mountain air and time in Southern Europe for 2000 years. Dry-cured ham is famous for its unique sensory characteristics such as the intense red colour and cured aroma. Sensory characteristics of dry cured ham are related to its physicochemical composition. Salting is one of the key steps in dry-cured ham processing; salt is bacteriostatic agent (Careri, Mangia, Barbieri, Bolzoni, Virgili and Parolari, 1993), contributes to the typical salty taste of dry-cured ham and influences the development of proteolysis phenomena (Arnau, Guerrero and Sarraga, 1998). Andres, Cava, Ventanas, Muriel & Ruiz (2004) reported that the flavor characteristics of Iberian ham were significantly affected by the amount of added salt. Thus, optimising the amount of salt added to raw ham is of particular significance for the dry-cured ham industry. Among the factors affecting the volatile compounds of hams, drying time is a major one (Bolzoni, Barbieri and Virgili, 1996). Although the duration of the drying time is different for each ham treatment type, the sufficient drying time is needed to allow the development of a desirable flavour for all treatments (Ruiz, Ventanas, Cava, Andres and Garcia, 1999).

We have good circumstances to make dry-cured ham meat source, ham, is cheap in Korea. However, Koreans have not used to taste raw ham traditionally due to its short history of meat processing. Therefore, dry-cured ham hasn't available on the commercial market.

The aim of this work was to analyze the effect of salt addition level and drying time on color, fatty acid compositions and sensory properties of dry-cured ham.

II. MATERIALS AND METHODS

Fifty four ham were obtained from local cross-bred swine farm (5-6 months, 100-110 kg). The hams were placed on shelves in a cold room held at 1-4℃ and salted in the lean part of the raw ham for four weeks. Three different treatments were formulated as follows: (1) The HS (high salt) group of 18 hams was salted with 70 g kg^{-1} salt (w/w), (2) The MS (middle salt) group of 18 hams was salted with 50 g kg^{-1} salt (w/w), (3) The LS (low salt) group of 18 hams was salted with 30 g kg^{-1} salt (w/w). All hams were held for four weeks at 1-4℃. After washing to remove salt from the surface, samples were processed according to Arnau et al. (1998). *Biceps femoris* muscles were removed from dry-cured hams and analyzed for color, fatty acid compositions and sensory properties. Color of *Biceps femoris* muscles was measured using a Minolta Chroma Meter CR-300 (Osaka, Japan) set for L* (lightness), a* (redness), b* (yellowness),

Chroma, and h° values. It was standardized with a white tile (D65 Y= 93.0, x = 0.3133, y = 0.3194). Total lipids were extracted using chloroform-methanol (2:1, v/v) according to the procedure of Folch, Lees & Stanley (1957). An aliquot of total lipid extract was methylated as described by Morrison and Smith (1964). Fatty acid methyl esters were analyzed by a gas chromatograph (Varian 3,800) fitted with a fused silica capillary column, omegawax 205 (30 m´ 0.32 mm ID, 0.25 mm film thickness). The injection port was at 250°C and the detector was maintained at 300°C. Results were expressed as percentages of the total fatty acid detected based on the total peak area (Cho, Park, Kim, Hwang & Lee, 2005). Sensory properties were assessed by a trained panel of 8 members, using a descriptive analysis method (Ruiz, Ventanas, Cava, Timon & Garcia, 1998) for six different properties. Results were analyzed using the General Linear Models (GLM) of the Statistical Analysis System (SAS, 1998). Significant differences were analyzed by Duncan's multiple range test at $p<0.05$.

III. RESULTS AND DISCUSSION

Effects of salt level and drying time on color of dry-cured ham

Table 1 shows the color of dry-cured hams in *Biceps femoris* muscles the processing of dry-cured hams with different salt content (70 g kg^{-1} HS, 50 g kg^{-1} MS and 30 g kg^{-1} LS) and processed different drying time (180, 270 and 360 days). CIE L^* (lightness) values of MS and LS groups were significantly ($p<0.05$) decreased as drying time increased. Salt level did not significantly ($p>0.05$) affected CIE $L^*$of dry-cured ham dried during 180 and 360 days. CIE a^* (redness) values of LS group were higher ($p<0.05$) than those of HS and MS groups during all drying time conditions and were significantly ($p<0.05$) increased as drying time increased. When drying period increased, CIE b^* (yellowness) values of all treatment groups were significantly ($p<0.05$) increased. Chroma and h° of MS and LS groups were significantly ($p<0.05$) increased as drying time increased.

Effects of salt level and drying time on fatty acid compositions of dry-cured ham

Table 2 shows the fatty acid compositions of dry-cured hams in *Biceps femoris* muscles the processing of dry-cured hams with different salt content (70 g kg^{-1} HS, 50 g kg^{-1} MS and 30 g kg^{-1} LS) and processed different drying time (180, 270 and 360 days). In the fatty acid compositions of all treatment groups, saturated fatty acid contents were significantly ($p<0.05$) increased, whereas unsaturated fatty acid contents were significantly ($p<0.05$) decreased as drying time increased. When salt addition level decreased, saturated fatty acid contents were significantly ($p<0.05$) decreased and unsaturated fatty acid contents were significantly ($p<0.05$) increased dried during 180 days and 270 days.

Effects of salt level and drying time on sensory properties of dry-cured ham

Table 3 shows the sensory properties of dry-cured hams in *Biceps femoris* muscles the processing of dry-cured hams with different salt content (70 g kg^{-1} HS, 50 g kg^{-1} MS and 30 g kg^{-1} LS) and processed different drying time (180, 270 and 360 days). In the sensory evaluation, fermentation aroma scores of MS group dried during 180 days and 360 days were higher than that of MS group dried during 270 days ($p<0.05$). Hardness scores of LS group were lower than those of the other groups for all drying period ($p<0.05$). When salt level decreased and duration of drying time increased, juiciness scores of dry-cured ham were more juicy ($p<0.05$). As salt addition level increased, saltiness scores of dry-cured ham were significantly ($p<0.05$) increased. Flavor intensity scores of HS and LS groups were significantly ($p<0.05$) increased as drying period increased.

IV. CONCLUSION

The salt level and drying time significantly affected color, fatty acid compositions and sensory properties of dry-cured ham. Lower salt addition level increased CIE a^*, chroma, unsaturated fatty acid contents and juiciness, and decreased saturated fatty acid contents, hardness and saltiness of dry-cured ham. With the increase of drying time, CIE L* of LS and MS group, unsaturated fatty acid contents and water activity of dry-cured ham were significantly decreased and Juiciness was significantly increased.

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Table 1. Effects of salt level and drying time on color characteristics of dry-cured ham

Item		Drying time (days)		
		180	270	360
CIE L*	HS	42.49±0.62	$39.12±0.45^{ab}$	39.42±1.92
	MS	$43.35±1.17^{A}$	$40.29±0.45^{Ba}$	$38.81±0.76^{B}$
	LS	$43.73±1.40^{A}$	$38.24±0.88^{Bb}$	$39.39±0.60^{B}$
CIE a*	HS	$10.93±0.21^{b}$	$12.09±0.54^{b}$	$11.63±0.38^{b}$
	MS	$11.59±0.32^{b}$	$11.78±0.18^{b}$	$12.14±0.36^{b}$
	LS	$13.25±0.34^{Ba}$	$13.27±0.30^{Ba}$	$14.67±0.31^{Aa}$
CIE b*	HS	$6.53±0.10^{Ba}$	$6.62±0.25^{B}$	$8.18±0.75^{A}$
	MS	$5.89±0.17^{Bb}$	$6.90±0.32^{AB}$	$7.60±0.60^{A}$
	LS	$6.28±0.10^{Ca}$	$7.36±0.18^{B}$	$8.45±0.31^{A}$
Chroma	HS	$12.74±0.18^{b}$	$13.80±0.50^{b}$	$14.00±0.48^{b}$
	MS	$13.01±0.34^{Bb}$	$13.67±0.14^{ABb}$	$14.36±0.52^{Ab}$
	LS	$14.67±0.31^{Ba}$	$15.19±0.25^{Ba}$	$16.94±0.39^{Aa}$
h°	HS	$30.88±0.67^{a}$	28.82±1.38	33.31±2.31
	MS	$27.02±0.56^{Bb}$	$30.29±1.40^{AB}$	$31.87±1.84^{A}$
	LS	$25.39±0.68^{Bb}$	$28.98±0.93^{A}$	$29.92±0.68^{A}$

HS: high salt, 70 g kg^{-1}; MS: middle salt, 50 g kg^{-1}; LS: low salt, 30 g kg^{-1}.

$^{A, B}$: Values with different superscripts in the same row differ significantly ($p<0.05$).

$^{a, b}$: Values with different superscripts in the same column differ significantly ($p<0.05$).

* Mean±standard error.

Table 2. Effects of salt level and drying time on fatty acid compositions (%) of dry-cured ham

Item		Drying time (days)		
		180	270	360
SFA	HS	$33.31±0.15^{Ca}$	$36.97±0.28^{Ba}$	$39.91±0.53^{Aab}$
	MS	$32.09±0.48^{Cb}$	$36.43±0.21^{Ba}$	$38.72±0.40^{Ab}$
	LS	$32.19±0.33^{Cb}$	$35.12±0.28^{Bb}$	$40.95±0.75^{Aa}$
USFA	HS	$66.69±0.15^{Ab}$	$63.03±0.28^{Bb}$	$60.09±0.53^{Cab}$
	MS	$67.91±0.48^{Aa}$	$63.57±0.21^{Bb}$	$61.28±0.40^{Ca}$
	LS	$67.81±0.33^{Aa}$	$64.88±0.28^{Ba}$	$59.05±0.75^{Cb}$

Mono-USFA	HS	50.53±0.50^{Ab}	50.28±0.62^{Ab}	46.32±0.90^{B}
	MS	53.44±0.36^{Aa}	50.83±0.74^{Bab}	48.74±1.14^{B}
	LS	53.22±1.02^{Aa}	52.57±0.32^{Aa}	46.86±0.41^{B}
Poly-USFA	HS	16.16±0.41^{A}	12.75±0.45^{C}	14.52±0.37^{B}
	MS	14.47±0.63	12.74±0.83	12.96±1.29
	LS	14.60±1.26	12.31±0.30	12.67±0.67

HS: high salt, 70 g kg^{-1}; MS: middle salt, 50 g kg^{-1}; LS: low salt, 30 g kg^{-1}.

$^{A-C}$: Values with different superscripts in the same row differ significantly ($p<0.05$).

$^{a, b}$: Values with different superscripts in the same column differ significantly ($p<0.05$).

* Mean±standard error.

Table 3. Effects of salt addition level and drying time on sensory properties of dry-cured ham

Item		Drying days		
		180	270	360
Redness	HS	6.73±0.30	7.22±0.30	6.78±0.19
	MS	6.72±0.31	6.53±0.13	6.75±0.34
	LS	6.49±0.36	6.67±0.27	6.67±0.17
Fermentation aroma	HS	6.82±0.24	5.95±0.39	6.72±0.19^{b}
	MS	6.66±0.09^{A}	6.10±0.29^{B}	6.70±0.10^{Ab}
	LS	6.62±0.93	7.11±0.54	7.35±0.22^{a}
Hardness	HS	6.00±0.30^{a}	5.79±0.32^{a}	6.17±0.29^{a}
	MS	4.86±0.12^{Bb}	5.47±0.12^{Aa}	5.72±0.25^{Aa}
	LS	4.24±0.31^{b}	4.46±0.21^{b}	4.87±0.30^{b}
Juiciness	HS	4.48±0.23^{Bc}	5.00±0.30^{ABb}	5.22±0.05^{Ab}
	MS	5.35±0.09^{Bb}	5.38±0.12^{Bab}	5.80±0.18^{Aa}
	LS	6.12±0.15^{ABa}	5.69±0.15^{Ba}	6.17±0.13^{Aa}
Saltiness	HS	7.76±0.12^{ABa}	7.40±0.24^{Ba}	7.95±0.12^{Aa}
	MS	6.63±0.16^{b}	6.45±0.23^{b}	7.15±0.28^{b}
	LS	5.64±0.10^{c}	5.96±0.23^{b}	5.97±0.17^{c}
Flavor intensity	HS	6.44±0.30^{Bab}	6.62±0.21^{AB}	7.23±0.16^{Aa}
	MS	6.65±0.19^{a}	6.28±0.18	6.60±0.25^{b}
	LS	5.47±0.47^{Bb}	6.39±0.29^{AB}	6.82±0.15^{Aab}

HS: high salt, 70 g kg^{-1}; MS: middle salt, 50 g kg^{-1}; LS: low salt, 30 g kg^{-1}.

$^{A, B}$: Values with different superscripts in the same row differ significantly ($p<0.05$).

$^{a-c}$: Values with different superscripts in the same column differ significantly ($p<0.05$).

* Redness: 0=pale pink, 10=dark red; fermentation aroma: 0=odourless, 10=very intens odour; hardness: 0=very tender, 10=very firm; juiciness: 0=extremely dry, 10=extremely juicy; saltiness: 0=not to very salty, 10=very salty; flavor intensity: 0=flavorless, 10=very intense flavor.

* Mean±standard error.