The effect of salt contents and $NaNO_2$ on fatty acids compositions and free amino acids contents of dry-cured ham processed under Korean environment

P.N. Seong[1*], J.H. Kim[1], S.H. Cho[1], B.Y. Park[1], K.H. Hah[1], M.O. Jung[1], D.G. Lim[1], H. Kim[1] & J.M. Lee[1]

[1]Animal Products and Processing Division, National Livestock Research Institute, 564 Omokchun-dong, Kwonsun-gu, 441-706, Suwon, Korea.

Introduction

Dry-cured hams are 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 represents the main cured product in Italy (Parma), Spain (Jamon), China (Jinhua), and U.S. (Country ham). 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 et al., 1993), contributes to the typical salty taste of dry-cured ham and influences the development of proteolysis phenomena (Arnau et al., 1998).

We have good circumstances to make dry-cured ham because the resources, ham, are chip and the weather conditions are very good for making it in Korea. However, Koreans have not had raw ham traditionally and have shorter history of meat processing, so they don't sell dry-cured ham now commercially. The aim of this work was to analyze the effect of salt content and $NaNO_2$ on fatty acids compositions, and free amino acids contents of dry-cured ham processed under Korean environment.

Materials and mMethods

Twelve thighs were obtained from local cross-bred swine (5-6 months, 100-110 kg) and processed into dry cured hams. Briefly, the hams were placed on shelves in a cold room held at 1-4□ and salted by individual addition of a controlled amount of salt in the lean part of the raw ham for four weeks. Four different treatments were considered: The HS group of 3 hams (11.3 kg) was salted with 9.2 g kg-1 salt (w/w) (high salt batch), the HS+NaNO2 group of 3 hams (10.65 kg) was salted same as HS group and added 100 ppm NaNO2. The LS group of 3 hams (11.42 kg) was salted with 6.2 g kg-1 salt (w/w) (Low salt batch), the LS+NaNO2 group of 3 hams (10.62 kg) was salted same as LS group and added 100 ppm NaNO2. All hams were held for further four weeks at 1-4□. After washing to remove salt from the surface, all hams were hung in outside for 8 months (4 months drying and 4 months aging). The hams were weighed in each of the stages of processing in order to calculate weight losses. Temperature and relative humidity of environment were measured daily at 3:00-4:00 p.m (Figure 1, 2). Biceps femoris muscles were removed from hams and analyzed for pH, proximate composition, and chemical parameters.

Total lipids were extracted using chloroform-methanol (2:1, v/v) according to the procedure of Folch et al. (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 3,600) fitted with a fused silica capillary column, omegawax 205 (30 m×0.32 mm ID, 0.25 μm 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 et al., 2005). Free amino acid content was measured in accordance with the methods reported by Henderson et al. (2000). One gram of muscle was homogenized in 5 ml 0.01 N HCl with a Polytron for 20s. The homogenate was used for determination of free amino acid content by reverse-phase HPLC (Agilent 1100, Agilent Technologies, USA). L-Citruline (98% purity, Sigma-aldrich, USA) was added as internal standard. Identification and quantification of amino acids were performed by comparison with standard amino acid mixtures (Amino acid standard, Agilent Technology, USA).

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 $p<0.05$.

Results and discussion

HS+$NaNO_2$ group had significantly higher saturated fatty acid than the other group, and LS group had significantly higher MUFA/SFA than HS+$NaNO_2$ group (Table 1). MUFA/SFA of LS group had higher than that of HS+$NaNO_2$ group. Free amino acid analysis revealed that there were high contents of glutamate (228.26-427.11 mg/100 g), alanine (356.03-579.47 mg/100 g), and lysine (377.88-685.06 mg/100 g) in

Biceps femoris muscles of dry-cured ham processed under Korean environment (Table 2). The processing conditions did not significantly affected free amino acid of *Biceps femoris* muscles, except for proline content ($P>0.05$). LS+$NaNO_2$ group had significantly higher proline content than HS+$NaNO_2$ group.

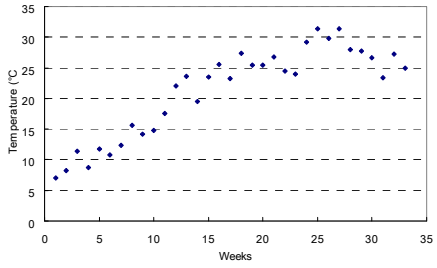

Figure 1. Temperature during drying and aging.

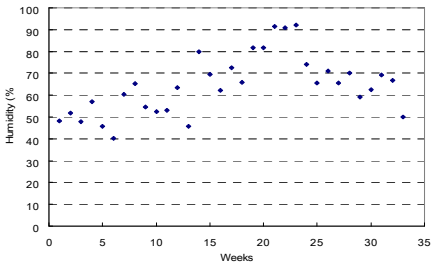

Figure 2. Relative humidity during drying and aging.

Table 1. The effects of salts content and $NaNO_2$ on fatty acids compositions of dry-cured ham processed under Korean environment

Item	**HS**	**HS+$NaNO_2$**	**LS**	**LS+$NaNO_2$**
SFA	35.77±0.62^{b}	38.00±0.61^{a}	34.31±0.11^{b}	35.14±0.78^{b}
USFA	64.23±0.62^{a}	62.00±0.61^{b}	65.69±0.11^{a}	64.86±0.78^{a}
mono-USFA	50.93±0.64	49.60±0.25	50.54±0.18	49.53±2.14
poly-USFA	13.30±0.53	12.40±0.40	15.15±0.21	15.33±2.18
n3	0.39±0.03	0.44±0.06	0.51±0.05	0.58±0.18
n6	12.91±0.52	11.96±0.34	14.64±0.18	14.75±2.00
n6/n3	33.34±1.34	27.88±2.81	29.31±2.64	28.05±4.63
MUFA/SFA	1.42±0.04^{ab}	1.30±0.03^{b}	1.47±0.01^{a}	1.41±0.07^{ab}
PUFA/SFA	0.37±0.02	0.33±0.02	0.44±0.01	0.44±0.06

HS : high salt [9.2 g kg^{-1} salt (w/w)] batch

HS+ $NaNO_2$: high salt [9.2 g kg^{-1} salt (w/w)] + $NaNO_2$ (100 ppm) batch

LS : low salt [6.2 g kg^{-1} salt (w/w)] batch

LS+ $NaNO_2$: low salt [6.2 g kg^{-1} salt (w/w)] + $NaNO_2$ (100 ppm) batch

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

* Mean±standard error

Table 2. The effects of salt contents and $NaNO_2$ on free amino acids contents of dry-cured ham processed under Korean environment

Item	HS	HS+$NaNO_2$	LS	LS+$NaNO_2$
Aspartic acid	175.20±62.73	107.55±25.00	164.48±5.86	163.82±18.15
Glutamic acid	427.11±161.80	228.26±36.20	346.68±16.22	348.63±25.92
Serine	180.58±59.24	122.28±16.46	160.12±16.04	159.12±21.02
Histidine	159.18±46.14	102.22±15.01	137.69±15.82	144.74±8.29
Glycine	173.95±52.66	116.55±14.40	157.78±12.19	175.10±13.16
Threonine	170.98±38.09	126.24±16.75	174.14±16.38	173.13±20.74
Arginine	268.83±89.59	173.36±27.52	207.29±50.39	192.21±17.76
Alanine	579.47±219.32	356.03±33.69	475.00±4.93	506.17±26.52
Tyrosine	132.80±22.09	99.35±2.52	120.61±15.26	127.58±5.50
Valine	278.96±55.73	224.62±21.21	292.49±22.40	311.26±26.84
Methionine	152.27±22.87	117.41±13.50	155.03±17.82	167.07±13.57
Phenylalanine	206.80±23.30	178.70±19.29	229.69±22.53	247.35±19.47
Isoleucine	200.97±29.18	161.54±17.57	219.07±23.50	227.08±16.28
Leucine	373.03±52.10	293.87±28.03	381.61±46.49	397.79±20.75
Lysine	685.06±271.64	377.88±59.89	533.93±25.95	538.01±41.30
Proline	246.52±33.77^{ab}	218.99±17.54^{b}	263.31±14.42^{ab}	303.08±19.59^{a}

HS : high salt [9.2 g kg^{-1} salt (w/w)] batch

HS+ $NaNO_2$: high salt [9.2 g kg^{-1} salt (w/w)] + $NaNO_2$ (100 ppm) batch

LS : low salt [6.2 g kg^{-1} salt (w/w)] batch

LS+ $NaNO_2$: low salt [6.2 g kg^{-1} salt (w/w)] + $NaNO_2$ (100 ppm) batch

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

* Mean±standard error

References

1. AOAC. 1995. Official methods of analysis. 16th ed. Association of Official Analytical Chemists. Washington, D. C.
2. Arnau, J., Guerrero, L. and Sarraga, C. 1998. The effect of green ham pH and NaCl concentration on cathepsin activities and the sensory characteristics of dry-cured hams. J Sci Food Agric. 77:387-392.
3. Careri, M., Mangia, A., Barbieri, G., Bolzoni, L., Virgili, L. and Parolari, G. 1993. Sensory property relationship to chemical data of Italian type dry-cured ham. J Food Sci. 58:968-972.
4. Cho, S. H., Park, B. Y., Kim, J. H., Hwang, I. H. and Lee, J. M. 2005. Fatty acid profiles and sensory properties of lingissimus dorsi, triceps brachii, and semimembranosus muscles from Korean Hanwoo and Australian angus beef. Asian-Aust. J. Anim. Sci. 18:1786-1793.
5. Folch, J., Lees, M. and Stanley, G. H. S. 1957. A simple method for the isolation and purification of lipids from animal tissues. J. Biol. Chem. 226:497-500.
6. Henderson, J. W., Ricker, R. K., Bidlingmeyer, B. A. and Woodward, C. 2000. Rapid, accurate, sensitive and reproducible HPLC analysis of amino acids. Agilent Technologies. http://www.agilent.com (assessed on August 3, 2004)
7. Morrison, W. R. and Smith, L. M. 1964. Preparation of fatty acid methyl esters and dimethylacetals from lipids with boron trifluoride-methanol. J. Lipid Res. 5:600-608.
8. SAS. SAS/STAT. 1998. SAS/STAT User's Guide: Statistics. SAS inst., Cary, NC.