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EVALUATION OF LIPID OXIDATION AND OXIDATIVE PRODUCTS AS AFFECTED BY MEAT CUT, PACKAGING METHOD AND STORAGE TIME DURING REFRIGERATED STORAGE

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Introduction

To extend the shelf-life, meat and meat products are refrigerated during storage. Although meat and meat products are stored under the refrigerated temperatures to reduce the microbial growth, lipid oxidation is one of the most important chemical deteriorations that affect the quality of meat and meat products. There are several methods to determine the degree of lipid oxidation. Peroxide values (POV) and thiobarbituric acid reactive substance (TBARS) values have been used as indices to assess the degree of lipid oxidation. However, these methods were not appropriates to measure the degree of lipid oxidation in meat and meat products because TBARS values only correlated with POV when fat contained three or more double-bond fatty acids (Gray, 1978). In addition, it has been reported that TBARS values couldn't measure the degree of oxidation of lipids containing mono- or di-unsaturated fatty acids (Decker et al., 1998). Due to decreases after maximum level of POV, long-period stored meat and meat products couldn't be measured by POV. Hexanal values in cooked chicken tended to rise with increasing storage time (Beltran et al., 2003). The relationship between current methods of lipid oxidation and volatile compounds during storage time should be explained to access the degree of lipid oxidation more accurately.

Objectives

The objectives of this study were to measure the degree of lipid oxidation as affected by pork meat cut, packing method and storage time on lipid oxidation, and to investigate the correlation between current methods of lipid oxidation and oxidative products produced by degradation of fatty acids during storage.

Methodology

Fresh pork loins and bellies were purchased from a wholesale meat markets in Gwangju, and analyzed pH, proximate composition, TBARS, FFA, and volatile oxidation products during refrigerated storage at 8°C. Chemical compositions were measured by the AOAC (1990) and pH was measured by pH meter. Lipid extraction was performed by the method of Folch et al. (1957). After extraction, extracts were evaporated and stored at

4°C until analyzed. TBARS and FFA values were conducted by the method of Witte et al. (1970) and AOCS (1987), respectively. Simultaneous distillation and extraction (SDE) was performed to extract the volatile oxidation products, with modified procedure of Heath and Reineccius (1986). Quantification and identification of volatile oxidation products were conducted by a gas chromatograph (GC) and mass spectrometer (MS). Total plate count (TPC) and violet red bile agar (VRB) have been used to determine total bacterial counts and coliform bacteria, respectively. Then, they were incubated at 37°C for 2 days and expressed as log cfu/g. The experiment was replicated triplicates, and the data were analyzed using two-way analysis of variance (ANOVA) in SPSS program, as factors for pork meat cut, packaging method and storage time. Means were separated by the Duncan's multiple range test.

Results & Discussion

Moisture, fat and protein contents of belly were 48.4, 38.5 and 10.2%, whereas those of loin were 73.5, 3.60 and 19.8%, respectively (Table 1). Belly fat content was higher ($p<0.05$) than loin, whereas moisture and protein contents of belly were lower ($p<0.05$) than those of loin. Since interactions between treatments (vacuum belly, aerobic belly, vacuum loin, aerobic loin) and storage time in all parameters were found ($p<0.05$), data were separated out by treatment and storage time (Table 2). Storage time did not affect ($p>0.05$) pH, and belly pH was higher than loin pH ($p<0.05$) due to high amount of fat in the belly cut. TBARS values increased ($p<0.05$) with increased storage time and belly had higher TBARS values ($p<0.05$) than loin in the latter period of refrigerated storage at 8°C. FFA values were also increased ($p<0.05$) as storage time increased, and loin had higher FFA values ($p<0.05$) than belly. But no differences ($p>0.05$) in pH, TBARS and FFA between vacuum and aerobic packaging were observed. After quantification of volatile compounds in belly and loin, approximately 23 compounds were identified and aldehydes (6), ketones (3), alcohols (3) and fatty acids (2) were the predominant compounds which were known to secondary by-products of lipid oxidation. Among aldehydes compounds, it was reported that hexanal was as an index to assess the degree of lipid oxidation due to increased hexanal contents with increased storage time (Beltran et al., 2003). However, hexanal values of this study were opposite trend. These results were partially due to the different extraction methods. In Table 2, hexadecanoic acid content extracted from belly were not affected ($p>0.05$) by storage time, whereas that of loin was increased ($p<0.05$) with increased storage time. Loin contained higher hexadecanoic acid content than belly in the latter period of storage. It was considered that hexadecanoic acid was to use as an index of lipid oxidation because it had high correlation coefficient with FFA ($p<0.01$) and TBARS ($p<0.01$). The correlation equations were as followed; Y (hexadecanoic acid content) = 0.12X (FFA) + 7.457, Y(hexadecanoic acid content) =2.654X (TBARS) +7.459 were developed.

Microbial counts are shown in Figure 1. It took 7 to 14 days to reach the total plate counts of vacuum and aerobic packed belly of 107 log cfu/g, respectively, and 14 and 21days for vacuum and aerobic packed loins, respectively. It was indicated that belly could be spoiled faster than loin due to the high amounts of fat, and vacuum packaging extended the shelf-life, as compared to aerobic packaging. These results were in agreement with results of previous studies (Sachindra et al., 2005; Duffy et al., 2000).

Conclusions

pH and TBARS values were higher in belly than loin in the latter period of storage, whereas FFA values were higher in loin than belly. Among the volatile compounds produced by fresh pork meats during refrigerated storage, aldehydes, ketones, alcohols and fatty acids were predominant. The amount of hexadecanoic (palmitic) acid in loin was increased with increased storage time. Thus, this oxidative compound might be an indicator to determine the degree of lipid oxidation in fresh pork loins. In addition, belly was spoiled faster than loin, and vacuum packaging extended shelf-life of fresh pork meats, as compared to aerobic packaging.

References

AOAC. 1990. Official Method of Analysis. 15th ed., Association of Official Analytical Chemists. Washington D.C.

AOCS. 1987. Official and Tentative Methods of the American Oil Chemists' Society Am. Oil Chem. Soc., BS 684: 1.5.

Beltran, E., Pla, R., Yuste, J., and Mor-Mur, M. 2003. Lipid oxidation of pressurized and cooked chicken: role of sodium chloride and mechanical processing on TBARS and hexanal values. J. Meat Sci. 64: 19–25.

Decker, E. A., Chan, W. K. M., and Faustman, C. 1998. TBA as an index of oxidative rancidity in muscle foods. In Proceedings of the 51st annual reciprocal meat conference (pp. 66). Kansas City. MO, USA.

Duffy, G., Walsh, D., Sheridan, J. J., Logue, C. M., Harrington, D., Blair, I. S., and McDowell, D. A. 2000. Behaviour of Listeria monocytogenes in the presence of Listeria innocua during storage of minced beef under vacuum of in air at 0°C and 10°C. Food Microbiol. 17: 571–578.

Folch, J., Lees, M., and Stanley, G. H. S. 1957. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem. 226: 497–509.

Gray, J. I., 1978. Measurement of lipid oxidation; A review. J. of Amer. Oil Chemists's Soc., 55: 539–546

Health, H. B., and Reineccius, G. 1986. Isolation of food flavours. In flavour chemistry and technology, eds. H. B. Heath and G. Reineccius. AVI, New York. Pp. 6.

Sachindra, N. M., Sakhare, P. Z., Yashoda, K. P., and Narasimha Rao, D. 2005. Microbial profile of buffalo sausage during processing and storage. Food Contr. 16: 31–35.

Witte, V. C., Krause, G. F., and Bailey, M. E. 1970. A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. J. Food Sci. 35: 582–585.

Tables and Figures

Table 1. Proximate composition(%) of belly and loin from pork

	Belly	Loin
Moisture	48.4 ± 6.02	73.5 ± 0.68
Crude fat	38.5 ± 9.89	3.60 ± 0.65
Crude protein	10.2 ± 3.05	19.8 ± 0.66
Total	97.1	96.9

Table 2. Change of pH, thiobarbituric acid reactive substances (TBARS), free fatty acid (FFA) and hexadecanoic acid (HA) as affected by meat cut, packaging method and storage time at 8°C.

			Storage time (days)					
Parameters	Parts	Packaging	0	3	7	14	21	28
pH	Belly	Vacuum	6.09^{A}	6.11^{A}	5.97^{AB}	5.91^{AB}	5.96^{AB}	6.11^{A}
		Aerobic	6.05^{bA}	6.18^{abA}	6.22^{abA}	6.10^{bA}	6.24^{abA}	6.39^{aA}
	Loin	Vacuum	5.57^{B}	5.56^{B}	5.52^{C}	5.48^{C}	5.45^{C}	5.44^{B}
		Aerobic	5.63^{B}	5.63^{B}	5.76^{BC}	5.62^{BC}	5.58^{BC}	5.74^{B}
TBARS[a] (MDA mg/kg)	Belly	Vacuum	0.17^{b}	0.37^{ab}	0.49^{ab}	0.56^{ab}	0.39^{abAB}	0.84^{aAB}
		Aerobic	0.13^{b}	0.53^{ab}	0.84^{ab}	0.72^{ab}	0.83^{abA}	1.23^{aA}
	Loin	Vacuum	0.07	0.16	0.15	0.24	0.18^{B}	0.23^{B}
		Aerobic	0.07^{b}	0.16^{ab}	0.24^{ab}	0.31^{a}	0.26^{abB}	0.36^{aB}
FFA[b] (%)	Belly	Vacuum	1.18^{abB}	1.03^{abB}	0.93^{bB}	1.18^{abC}	1.57^{abB}	1.82^{aB}
		Aerobic	1.09^{cB}	1.09^{cB}	1.22^{cB}	1.57^{bcBC}	2.15^{bB}	3.17^{aAB}
	Loin	Vacuum	4.40^{bA}	3.57^{bA}	4.67^{bA}	3.87^{bB}	7.25^{aA}	7.57^{aAB}
		Aerobic	3.56^{cA}	4.33^{abA}	5.12^{abA}	6.92^{bA}	7.48^{bA}	13.0^{aA}
HA[c] (/g)	Belly	Vacuum	0.22	0.58	0.35	0.72^{AB}	0.41^{C}	0.36^{B}
		Aerobic	0.05	0.16	0.28	0.31^{B}	0.74^{BC}	0.48^{B}
	Loin	Vacuum	0.31^{c}	0.47^{c}	0.77^{bc}	1.21^{AB}	2.27^{aA}	1.71^{abA}
		Aerobic	0.18^{c}	0.44^{c}	0.63^{bc}	1.60^{A}	2.00^{abAB}	3.07^{aA}

aTBARS – thiobarbituric acid reactive substance; bFFA – free fatty acid; cHA hexadecanoic acid.

a–cMeans with a same superscript within a row are not significantly different ($p>0.05$).

A–CMeans with a same superscript within a column are not significantly different ($p>0.05$).

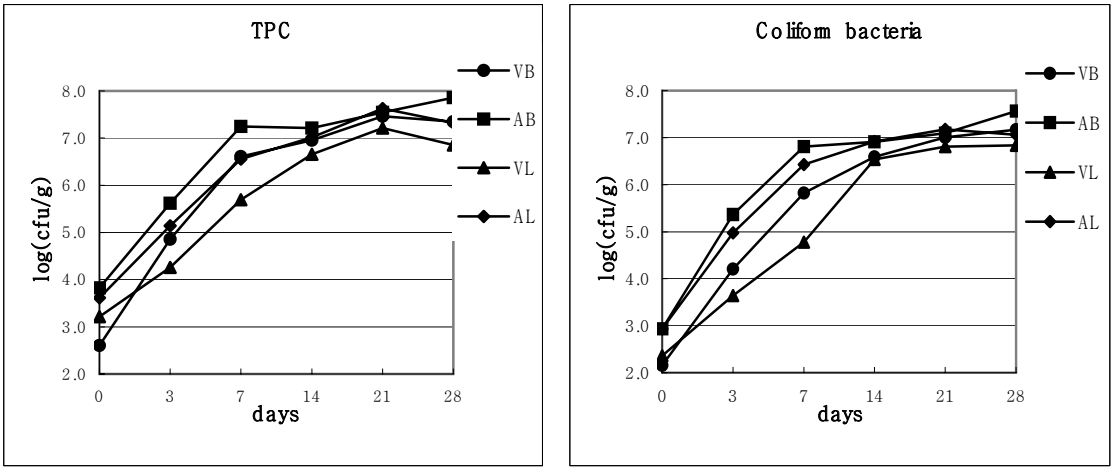

Fig. 1. Microbiological changes of pork belly and loin cuts as affected by meat cut, packaging method and storage time at 8°C.
VB – vacuum belly; AB – aerobic belly; VL – vacuum loin; AL – aerobic loin.