EFFECT OF DIETARY PALM OIL SUPPLEMENTATION ON THE MEAT QUALITY OF HANWOO (KOREAN CATTLE) BEEF DURING STORAGE

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***Abstract*—the objective of this research was to investigate the effect of dietary palm oil supplementation on the meat quality parameters and storage quality of Hanwoo (Korean cattle) beef. Eight 30-months-old steers were assigned into two groups and fed on a concentrate with 10% palm oil or without palm oil (control) for 3 months prior to slaughter. The samples of *M. longissimus* were collected from carcasses and stored at 4℃ for 9 days. The pH value, myofibrillar fragmentation index, total reducing ability, and flavor pattern with electronic nose were not affected by palm oil supplementation. The palm oil group had fatter (P<0.05) and more tender (P<0.05) meat, higher water-holding capacity (P<0.05), and lower polyunsaturated fatty acids content (P<0.05) than the control. During storage, the palm oil group showed the inhibitory effect on the TBARS level and metmyoglobin formation as well as lighter (P<0.05) and redder (P<0.05) meat color, compared with the control. Consequently, supplemental palm oil improved the marbling, water-holding capacity, tenderness, color stability, and lipid oxidation stability in beef.**

***Index Terms*—palm oil, beef quality, Hanwoo, marbling, oxidation stability.**

I. INTRODUCTION

The kind of fat in animal dietary determines the quality and healthfulness of meat products, because its fatty acid components are deposited in muscles (Scollan, Hocquette, Nuernberg, Dannenberger, Richardson, & Moloney, 2006). It is well-known that vegetable oils contain the higher concentration of polyunsaturated fatty acids (PUFA) compared with animal fats (Choi et al., 2010). The enrichment of PUFA (especially n-3 PUFA) in meat fat is beneficial to consumer's health, as it is connected with the prevention of chronic diseases, such as cancer and coronary heart disease (Carleton et al., 1991; Rose & Connolly, 1999). Many studies have found that supplemental vegetable oils increase the PUFA content in beef (Noci, French, Monahan, & Moloney, 2007), pork (Realini, Duran-Montgé, Lizardo, Gispert, Oliver, & Esteve-Garcia, 2010), and chicken meat (López-Ferrer, Baucells, Barroeta, Galobart, & Grashornt, 2001). Unfortuna -tely, supplemental PUFA causes the lipid oxidation and discoloration (Vatansever, Kurt, Enser, Nute, Scollan, Wood, & Richardson, 2000). On the other hand, palm oil, one of vegetable oils, contains the high concentration of saturated fatty acids (especially palmitic acid (C16:0)) (Sambanthamurthi, Sundram, & Tan, 2000) and is currently sold as animal dietary. In previous study in beef (Partida, Olleta, Sañudo, Albertí, & Campo, 2007), the effect of supplementation of palm oils versus mixed animal fats on the meat fatty acids and sensory quality is estimated. However, there is little information on the other meat quality parameters and storage quality in beef. Therefore, in this research, we conducted to investigate the effect of dietary palm oil supplementation on the meat quality parameters of Hanwoo (Korean cattle) beef during refrigerated storage.

II. MATERIALS AND METHODS

A. Animals and diets

Experimental animals were reared for 3 months prior to slaughter at the farm of Hoengseong County, Gangwondo, South Korea. Eight 30-months-old Hanwoo (Korean cattle) steers were assigned to two groups of 4 animals each for different feeding treatments and housed in 8×4 m^2 pens (4 animals per pen) bedded with sawdust in 10 cm-thickness. All animals were fed daily on 10 kg of commercial concentrates and 1 kg of rice straw. Each group was adapted to concentrate with 10% palm oil (Bergalac, Berg & Schmidt sdn. Bhd., Malaysia) or without palm oil (control). Dietary palm oil was rumen-stable form of calcium soaps and combined with rumen-stable carbohydrate. It contained 8,400 kcal/kg of metabolizable energy, 84% crude fat, 9% calcium, and fatty acids composing of 1.5% myristic acid (C14:0) and shorter fatty acids, 75% palmitic acid (C16:0), 8.3% palmitoleic acid (C16:1n-7) and stearic acid (C18:0), 10%

oleic acid (C18:1n-9), and 2% linoleic acid (C18:2n-6).

B. Sample preparation

After finishing, all animals were electrically stunned and slaughtered by exsanguination at a local abattoir. The carcasses were split centrally and chilled at -2℃ for 24 hr. The ***M. longissimus*** at the 11th to 13th thoracic vertebra was collected from right side of each carcass. For cooking loss and shear force value measurements, samples were cut into 2 cm-thickness. For other meat quality parameters measurements, those were cut into 1 cm-thickness, individually packaged in a low density polyethylene zipper bag (Clean zipper bag, Cleanwrap Co., Ltd., South Korea), and then stored at 4℃ for 9 days.

C. Meat quality parameters

Intramuscular fat content (%) was determined by a Soxhlet extraction method (AOAC, 1995). The extraction and methylation of total lipid was performed according to Folch, Lees, & Stanley (1957) and AOAC (1995), respectively, and fatty acid methyl esters were measured using a gas chromatography (6890N, Agilent Technologies, USA) equipped with a HP-Innowax fused silica capillary column (30 m length×0.25 mm id×0.50 μm film thickness) and a flame ionization detector. The pH value was measured using a pH meter (Seveneasy pH, Mettler-Toledo GmbH, Switzerland). Water-holding capacity (%) was determined as described by Hofmann, Hamm, & Blüchel (1957). Warner-Bratzler shear force value was measured using a texture analyzer (TA-XT2*i*, Stable Micro Systems Ltd., UK) and expressed as a maximum force (kgf) of resulted peak. Myofibrillar fragmentation index (MFI) was determined as described by Culler, Parrish, Smith, & Cross (1978) at 9 day of storage and calculated as unit myofibril per 0.5 milligram protein. Total reducing ability was determined as described by Lee, Cassens, & Fennema (1981) and expressed as an absorbance of blank (1 mM $K_3Fe(CN)_6$) minus absorbance of the sample. The TBARS (2-thiobarituric acid reactive substances) level was determined as described by Sinnhuber and Yu (1977) and calculated as milligram malonaldehyde per kilogram meat. Metmyoglobin concentration was measured using a spectrophotometer (UV-2401PC, Shimadzu, Japan) according to Krzywicki (1979) method and expressed as a percentage (%) of total surface myoglobin by Demos, Gerrad, Mandigo, Gao, & Tan (1996). The CIE L^* value and a^* value were measured using a chroma meter (CR-400, Konica Minolta Sensing, Inc., Japan). Flavor pattern was measured using an electronic nose (FOX 3000, Alpha MOS, Toulouse, France) equipped with the 12 metal oxide sensors and an autosampler (HS 100, Alpha MOS, Toulouse, France) and analyzed by the principal component analysis of Alpha Software (Alpha soft version 8.01).

D. Statistical analysis

All data were analyzed using ANOVA (Analysis of variance) of SAS (1999) program. Significant differences among means were tested by Student t-test at 5% level.

III. RESULTS AND DISCUSSION

The effect of dietary palm oil supplementation on the intramuscular fat content, pH value, water-holding capacity, Warner-Bratzler shear force value, myofibrillar fragmentation index, and total reducing ability of Hanwoo (Korean cattle) beef is represented in Table 1. The palm oil group had significantly higher intramuscular fat content ($P<0.05$) and higher water-holding capacity ($P<0.05$) compared with the control. Also, it had significantly lower Warner-Bratzler shear force value ($P<0.05$). But there were no significant differences in pH value, myofibrillar fragmentation index, and total reducing ability between two groups. In these results, the increases of water-holding capacity and tenderness would be due to the increase of marbling (Barton-Gade, 1987). In the results of fatty acid composition (Table 2), the palm oil group had significantly lower polyunsaturated fatty acids content ($P<0.05$) compared with the control. But there were no significant differences in saturated fatty acids, monounsaturated fatty acids, and n-6/n-3 ratio between two groups.

Flavor patterns (Fig. 1) were not different between two groups, because the discrimination index was minus 10 and the graphs from the two groups were overlapped. The effect of dietary palm oil supplementation on the TBARS level, metmyoglobin concentration, and meat color of Hanwoo beef during refrigerated storage is represented in Table 3. The TBARS level and metmyoglobin concentration increased in two groups during storage. But, after 6 days, the palm oil group had significantly lower values ($P<0.05$) in two parameters compared with the control. In addition, metmyoglobin concentration of the control exceeded 40%, consumer's rejection range reported by Green, Hsin, & Ziper (1971), after 6 days. With regard to meat color, during storage, L^* value decreased in the control and a^* value decreased in two groups. Also, the palm oil group showed significantly higher L^* value ($P<0.05$) and a^* value ($P<0.05$) compared with the control.

IV. CONCLUSION

In this research, the effect of dietary palm oil supplementation on the meat quality parameters including storage quality of Hanwoo (Korean cattle) beef was investigated. The supplementation of 10% palm oil in a concentrate increased the water-holding capacity and tenderness with higher marbling. An increase of marbling in Hanwoo beef promotes the economical gain, because the Korean beef industry highly regards the marbling among beef quality traits. In addition, supplemental palm oil led to a favorable color and improved the oxidation stability, that is the storage quality.

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Table 1
Effect of dietary palm oil supplementation on the intramuscular fat content, pH value, water-holding capacity, Warner -Bratzler shear force value, myofibrillar fragmentation index, and total reducing ability of Hanwoo (Korean cattle) beef

Parameter	Control	Palm oil
Intramuscular fat (%)	14.59±3.94[b]	20.57±1.62[a]
pH	5.55±0.01	5.65±0.12
Water-holding capacity (%)	46.46±4.18[b]	52.22±3.60[a]
Warner-Bratzler shear force (kgf)	6.23±1.91[a]	4.40±0.77[b]
MFI[1)] (unit myofibril/0.5 mg protein)	165.28±12.63	159.25±12.51
Total reducing ability	0.63±0.01	0.64±0.01

[a-b] Means±standard deviation in the same row with different letters differ significantly ($P<0.05$).

[1)] Myofibrillar fragmentation index.

Table 2
Effect of dietary palm oil supplementation on the fatty acid composition of Hanwoo (Korean cattle) beef

Parameter	Control	Palm oil
Saturated fatty acids	42.73±2.86	44.93±2.72
Monounsaturated fatty acids	54.07±2.84	52.21±2.80
Polyunsaturated fatty acids	3.20±0.21[a]	2.86±0.40[b]
n-6/n-3	11.50±1.63	13.32±3.09

[a-b] Means±standard deviation in the same row with different letters differ significantly (P<0.05).

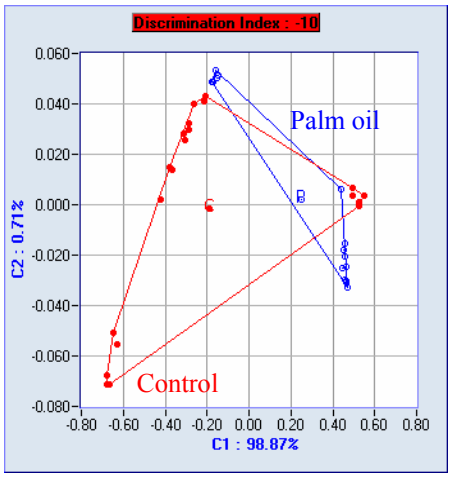

Fig. 1. Effect of dietary palm oil supplementation on the flavor pattern of Hanwoo (Korean cattle) beef. The C1 and C2 represent the components which are classified depending on the level of information from the electronic nose data. The points represent the sensor responses of all samples. The lines connect the outer points of all groups. The discrimination index represents the degree of discrimination between all groups. Higher is the discrimination index, better is the discrimination.

Table 3
Effect of dietary palm oil supplementation on the TBARS level, metmyoglobin concentration, and meat color of Hanwoo (Korean cattle) beef during storage at 4℃

Parameter	Storage time (day)	Control	Palm oil
TBARS (mg malonaldehyde/kg)	0	0.27±0.02 [C]	0.26±0.03 [C]
	3	0.29±0.03 [C]	0.28±0.03 [C]
	6	0.37±0.04[a B]	0.32±0.03[b B]
	9	0.46±0.03[a A]	0.38±0.03[b A]
Metmyoglobin (%)	0	26.51±2.74 [D]	25.61±2.57 [D]
	3	30.82±3.54[a C]	28.43±2.30[b C]
	6	42.92±9.44[a B]	30.31±2.25[b B]
	9	50.58±8.21[a A]	30.98±2.72[b A]
L^* (Lightness)	0	43.07±2.76[b A]	45.42±2.58[a B]
	3	41.62±3.12[b B]	44.83±2.67[a B]
	6	41.80±3.69[b B]	45.21±2.82[a B]
	9	40.57±3.66[b C]	46.42±2.86[a A]
a^* (Redness)	0	19.65±2.43[b A]	22.94±1.71[a A]
	3	18.32±2.28[b B]	21.45±1.57[a B]
	6	15.73±3.73[b C]	20.70±1.64[a C]
	9	14.61±1.31[b D]	19.14±1.81[a D]

[a-b] Means±standard deviation in the same row with different letters differ significantly (P<0.05).
[A-D] Means±standard deviation in the same column with different letters differ significantly (P<0.05).