EFFECTS OF DIFFERENT HAY SUPPLEMENTATION ON MEAT QUALITY AND FATTY ACID COMPOSITION OF HANWOO STEERS AT FINISHING PERIOD

You Jin Jung[1], Yeon Soo Park[2], Dicky Tri Utama[1], Muhlisin[3], Ji Hye Choi[1], Seung Gyu Lee[1] and Sung Ki Lee[1]

[1] College of Animal Life Sciences, Kangwon National University, Chuncheon 200-701, Republic of Korea

[2] Kangwon Animal Research Center, Wonju 220-952, Republic of Korea

[3] Faculty of Animal Science, Gadjah Mada University, Yogyakarta 55281, Indonesia

Abstract – Twenty five Hanwoo steers (628 ± 61.84 kg) were fed *ad libitum* concentrate for 180 days with one of four supplementary forages: straw as control (CS), local hay (LH), imported hay (IH) and haylage made up of local hay (HG). The *longissimus dorsi* of Hanwoo fed with LH led to the tender characteristics with the highest crude fat content, redness, yellowness (p<0.05) and omega-3 fatty acids content (p<0.01). The fatty acid composition of loin differed in the content of eicosapentaenoic acids (p<0.01), total monounsaturated fatty acids, oleic and omega-6 to omega-3 ratio (p<0.05). Loin from the LH treatment tended to have lower omega-6 to omega-3 ratio. CS loin samples had the least malondialdehyde (MA) content among the others (p<0.05), however, chilled storage at 2ºC for 6 days did not promote lipid oxidation significantly (p>0.05). Thus, LH supplementation is considered to be applied in Hanwoo feedlot industry.

Key Words – Beef, forage, omega-3.

I. INTRODUCTION

Numerous factors influence the profitability of beef cattle industry including feed costs, animal performance and beef quality. On the other hand, consumer demand on healthier meat increases continuously. Recently in Korea, finishing system for Hanwoo steers is to have them to consume a high concentrate diet for getting the best animal performance and quality of their meat. Thus, the beef contains high amount of saturated fatty acids (SFA) and an imbalance omega-6 to omega-3 ratio (10:1), in which the recommended ratio is 2:1 [1]. Developing a new finishing system is important to minimize the costs and to achieve healthier Hanwoo beef.

Many studies were conducted to achieve the same goals such as offering omega-3 rich oils to the cattle, increasing the proportion of forage, or grazing on pasture during finishing. This, however, may modify the desirable characteristics, mostly color, tenderness, and flavor of the meat, when compare with grain-fed beef [2]. Therefore, the objective of this study was to evaluate the effects of different hay supplementation on meat quality and fatty acid composition of Hanwoo steers fed *ad libitum* concentrate.

II. MATERIALS AND METHODS

Diets

Four different diets were used as treatments along with *ad libitum* commercial concentrate (crude protein, 12% and TDN, 70%), as follows; CS, LH (*Dactylis glomerata L.*, *Phleum pratense*, *Trifolium sp.*, and *Pleuraphis mutica*), IH (*Phleum pratense*), and HG made from LH. The proximate composition of forage is shown in Table 1. Proximate composition, calcium and phosphor content were determined by AOAC official methods [3]. Detergent analysis was used for determining fiber content [4].

Table 1 General composition (dry matter basis) of supplementary forages

Composition (%)	CS	LH	IH	HG
Moisture	10.6	10.4	11.3	12.83
Crude protein	6.02	7.43	9.41	12.32
Crude fat	1.72	2.66	2.20	4.60
Crude fiber	32.02	37.43	36.53	29.93
Ash	8.32	7.73	6.39	7.71
Calcium	1.24	1.22	1.17	1.04
Phosphor	0.63	0.52	0.65	0.55
ADF	39.77	41.79	38.44	33.23

NDF	66.63	76.51	68.55	66.08

ADF, acid detergent fiber; NDF, neutral detergent fiber

Animals

A total of 25 finished Hanwoo steers (25 ± 1 month-old) were randomly allocated to four group pens (5 x 10 m^2) and fed for 150 days at Kangwon Animal Research Farm. Each pen consisted of six animals with one diet treatment (excluding haylage group consisted of seven animals). Average daily dry matter intake was 0.93 kg/day for supplementary forage. Concentrate was given *ad libitum* after forage and free access to water. The average final weight was 761 ± 68.65 kg. After feeding period, the animals were stunned with captive bolt and slaughtered at the abattoir using standard procedure. The *longissimus dorsi* muscle of each animal was taken from the left carcass for analysis. The meats were packed in high density polyethylene zipper bags, distributed to laboratory and stored at -24ºC until required.

Proximate, instrumental surface colour, pH and shear force

Proximate composition was determined by AOAC official methods [3]. The surface color of 1-h bloomed samples was recorded by measuring CIE lightness (L*), redness (a*) and yellowness (b*) using a chromameter (CR-400, Konica Minolta Sensing Inc., Japan). The pH value of the homogenized samples were recorded using a pH meter (SevenEasy pH, Mettler-Toledo GmbH, Switzerland). For shear force measurement, 2.5 cm thick-samples were cooked in the high-density polyethylene zipper bags until internal temperature of 72°C was reached by immersing in water bath. The cut sample (1 x 1 x 1 cm^3) was cut through as the blade moved down with assay parameters were pre-test speed, 2.0 mm/s; test speed, 2.0 mm/s; post-test speed, 5.0 mm/s.

Fatty acid composition

Fatty acid composition was determined using a gas chromatography (YL6500, YL Instrument, Korea). Lipid was extracted according to Folch *et al.* [5] with chloroform-methanol (2:1 v/v). Fatty acids were converted into methyl esters as described by AOAC [3]. Fatty acid methyl esters were separated using an Omegawax-320 fused silica capillary column (30 m × 0.32 mm i.d., 0.25 µm film thickness; Supelco, Inc., USA). The fatty acid peaks were identified and quantified by comparing with the retention time and peak area of fatty acid standard mixtures (Supelco 47015-U).

Lipid oxidation

Lipid oxidation was evaluated using TBARS method as described by Sinhuber and Yu [6]. The results were calculated as mg malondialdehyde (MA) per kg meat.

Statistical analysis

A 4 x 3 factorial design with four replicates was employed for lipid oxidation analysis with diet treatments and storage time as main effects using two-way analysis of variance (ANOVA). However, no interactions were observed. Other data were subjected to one-way ANOVA using R-version 3.1.2 with "Agricolae" library (The R-foundation for Statistical Computing, Austria). The statistical significance of the differences between means from different treatments was determined by Duncan's multiple range test ($p \leq 0.05$).

III. RESULTS AND DISCUSSION

Meat quality attributes such as colour, tenderness, lipid content and composition and oxidative stability are important to be evaluated. Breed, diets, pre-slaughter handling, slaughter method, and storage conditions are the main factors affecting these quality attributes [7].

Table 2 Physicochemical properties of *longissimus dorsi* obtained from Hanwoo fed with different supplementary hay

Parameter	CS	LH	IH	HG	SEM
No. of observations	6	6	6	7	
Moisture (%)	67.51 ^{a}	63.09 ^{b}	64.84 ^{ab}	66.26 ^{ab}	0.71
Crude protein (%)	21.97	20.30	21.43	21.00	0.43
Crude fat (%)	10.99 ^{b}	17.33 ^{a}	14.96 ^{ab}	14.37 ^{ab}	0.95
Ash (%)	0.89 ^{a}	0.80 ^{b}	0.70 ^{c}	0.69 ^{c}	0.02
WBSF (kg)	5.84 ^{ab}	4.74 ^{b}	4.71 ^{b}	6.48 ^{a}	0.29
pH	5.60	5.63	5.60	5.62	0.01
Lightness (*L**)	42.89	44.20	42.71	42.29	0.53
Redness (*a**)	20.80 ^{ab}	21.32 ^{a}	18.82 ^{c}	19.19 ^{bc}	0.35
Yellowness (*b**)	10.39 ^{ab}	10.83 ^{a}	9.46 ^{bc}	9.30 ^{c}	0.21

SEM, standard error of the means; $^{a\text{-}c}$ Means within each row with different superscripts are significantly different ($p<0.05$); WBSF, Warner-Bratzler shear force.

The effects of supplementary feeding with straw, hay or haylage during finishing period of Hanwoo steers were observed in this study. Local hay diet led to higher crude fat content ($p<0.05$). However, no effects were found on meat crude protein ($p>0.05$). Supplementation with local hay (higher fiber content) tended to improve the deposition of meat fat and tenderness. This high fat content affected the tenderness of the cooked samples, which agrees with Wood *et al.* [8] that total lipid content in muscle plays role in the tenderness. As shown in Table 2, local hay diet beef was tenderer than the others ($p>0.05$). In this study, no effects were found ($p>0.05$) on meat pH among diet treatments. Meat pH values were within the normal range of beef tenderloin ($5.5<pH<5.8$). Meat pH is mostly affected by pre-slaughtering handling instead of diets [9].

Table 3 Fatty acid composition (%) of *longissimus dorsi* obtained from Hanwoo fed with different supplementary hay

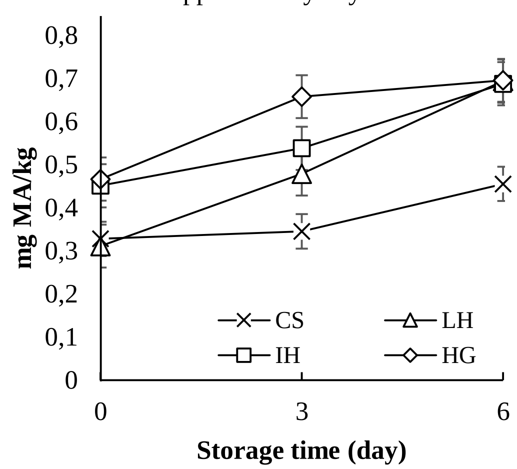
Compound	CS	LH	IH	HG	SEM
No. of observations	6	6	6	7	
C14:0	3.87	4.64	4.64	4.45	0.12
C16:0	27.25	29.77	26.32	29.17	0.65
C16:1n-7	5.37	4.62	5.18	5.23	0.22
C18:0	9.18	9.69	9.77	9.66	0.20
C18:1n-9	50.21^{a}	46.51^{b}	49.96^{a}	47.35^{ab}	0.56
C18:2n-6	2.61	2.40	2.21	2.60	0.07
C18:3n-3	0.10	0.10	0.10	0.10	0.0001
C20:1n-9	0.36	0.20	0.29	0.36	0.03
C20:4n-6	0.45	0.38	0.48	0.50	0.05
C20:5n-3	0.60^{ab}	1.04^{a}	0.43^{b}	0.48^{b}	0.11
C22:4n-6	ND	0.24	0.23	0.10	0.03
C22:6n-3	ND	0.40	0.39	ND	0.002
SFA	40.30	44.11	40.73	43.28	0.65
MUFA	55.94^{a}	51.34^{b}	55.43^{a}	52.93^{ab}	0.65
PUFA	3.76	4.55	3.84	3.78	0.15
n-3	0.70^{b}	1.54^{a}	0.92^{b}	0.58^{b}	0.12
n-6	3.06	3.02	2.92	3.20	0.10
n-6/n-3	4.38^{ab}	1.96^{c}	3.18^{bc}	5.55^{a}	2.75
PUFA/SFA	0.09	0.10	0.09	0.09	0.004
SFA/(UFA)	0.68	0.79	0.69	0.76	0.02

SEM, standard error of the means; ND, not detected; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; UFA, unsaturated fatty acids; $^{a-c}$ means within each row with different superscripts are significantly different ($p<0.05$).

Color, which is the first characteristic noticed by consumers, plays an important role as an indicator of meat quality. LH loin samples showed the reddest with high yellowness ($p<0.05$) as represented by the highest CIE a* and b* values. Priolo *et al.* [10] found that grazing animals get more iron from grass resulting high haemoglobin content in meat, whereas the yellowness is due to β-carotene content, which is derived from plants. Therefore, meat fat from grazing animals is more yellow than that of grain-based diet animals. These results suggest that supplementation with LH during fattening period could also improve meat redness of finished steer.

Twelve fatty acids were detected in the beef samples from both local and imported hay fed Hanwoo with a minimum percentage cut-off of 0.10%, while adrenic acid (22:4n6) was not detected in control sample and docosahexaenoic acid (DHA, 22:6n3) was not found in control and haylage samples. Table 3 shows that local hay samples had the lowest oleic acid (18:1n9) but rich of eicosapentaenoic acid (EPA, 20:5n3). Therefore, local hay samples had less MUFA but had significantly higher omega-3 fatty acids than other treatments ($p<0.01$). As the result, the omega-6 to omega-3 ratio was significantly lower in LH beef ($p<0.05$). Since essential fatty acids cannot be synthesized by mammals due to the absence of necessary enzymes [11]. Scollan *et al*. [12] reported that hay can be used to manipulate fatty acid composition in beef.

Figure 1. TBARS values of *longissimus dorsi* obtained from Hanwoo fed with different supplementary hay



As *longissimus dorsi* contains high intramuscular fat, it becomes easier to get oxidized during storage. TBARS values figure out the lipid oxidation during six days of chilled storage (Fig 1). HG samples had the highest malondialdehyde content followed by IH, CS, and LH as the least oxidative at initial day. After 6 days of storage, only CS samples showed the stability, maintained lower than the others. However, chilled storage at 2 °C until 6 days did not promote lipid oxidation significantly ($p>0.05$). Jakobsen and Bertelsen [13] reported that the TBARS value increased faster at temperature higher than 5 °C. Moreover, the degree of unsaturation of the fatty acids affect lipid oxidation besides environmental factors. Although unsaturated fatty acids ratios among treatments were not significantly different, the oxidation rate of HG samples was higher than that of LH. Other internal factors such as the levels of released iron or self-defense enzymes against lipid oxidation might influence it [14]. However, those parameters were not observed in this study.

IV. CONCLUSION

Loin obtained from Hanwoo fed LH had the best overall quality traits among other diet treatments. Therefore, supplementation with LH during finishing could improve meat colour, tenderness, and fatty acid composition of the *longissimus dorsi* of Hanwoo steers.

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