PE7.21 Effects of the Length of Feeding of Barley-based Diet on Fatty Acid Composition and Sensory Quality of Hanwoo Longissimus Muscle 225.00

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***Abstract*—The effects of the length of feeding of whole-crop barley silage and barley-based concentrates on the fatty acid composition and sensory quality attributes of the longissimus muscle of Hanwoo (Korean native cattle) were determined. Hanwoo steers, 8 months of age, were assigned to either the short term feeding (fed until 26 months of age) or long term feeding group (fed until 32 months of age). Strip loin samples were taken after a 24 hr chill. Each loin was divided into two portions and was assigned to either the 1-day aging or the 10-day aging group. The length of feeding and the aging period did not alter the fatty acid composition of the *longissimus* muscle. Juiciness score was significantly higher in beef from the long term-fed group, while other eating quality traits were not influenced by the length of feeding. Aging improved tenderness, overall acceptability and rating of beef. Feeding of Hanwoo steers with barley-based diets for either 26 or 32 months of age produced beef with similar fatty acid profile, tenderness, flavor, overall acceptability and rating. The current data imply that except for juiciness there is no further improvement in sensory traits of Hanwoo *longissimus* muscle that can be attained beyond 26 months.**

***Key words:* barley-based diet, fatty acid composition, feeding system, sensory quality**

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I. INTRODUCTION

BEEF quality partly depends on fatty acid composition [18]. The fatty acid composition of beef is affected by the time on feed and the type of diet as revealed by several researches. Saturated fatty acids (SFA) increased [23], monounsaturated fatty acids (MUFA) increased[1] and polyunsaturated fatty acid (PUFA) decreased[8] as feeding with high concentrate diets increased. Several studies have demonstrated that the time on feed had only a small effect on the fatty acid composition of beef as compared with the type of diet [1].

The fatty acid profile of beef affects sensory traits. PUFA was reported to have a negative relationship with tenderness and flavor while oleic acid was positively associated with taste panel tenderness and flavor ratings. In addition, fatty acids influence fat tissue firmness, shelf life (oxidative stability) and flavor. The length of feeding influences sensory attributes of beef. Longer time on high concentrate diets resulted in higher beef flavor intensity [2], tenderness and overall acceptability [10]. Some studies revealed that feeding period had little influence on the cooking properties and palatability of beef [5, 7].

Postmortem aging of beef has been a common practice because it influences the sensory quality of meat. Aging improves tenderness of meat through proteolysis of myofibrillar proteins. In addition, sensory profile of beef improved with increased postmortem aging [11].

Hanwoo cattle raisers have explored the use of whole-crop barley diets over the traditional concentrate and rice straw diet. Recently, the length of feeding was increased from 24 months to 30-32 months. The effect of this management system on Hanwoo meat quality has not been determined. The feeding strategy that utilizes whole-crop barley diets in raising Hanwoo steers that will ensure the production of good quality beef has yet to be established. On this regard, the feeding of barley diets at two different feeding periods was evaluated. The study aimed to determine the effect of the length of feeding barley-based diets on the fatty acid composition and sensory quality of beef. The effect of aging on the quality of the resultant meat was also investigated.

II. MATERIALS AND METHODS

A. Animals, sample collection and experimental design

Hanwoo were raised by chosen private feedlot beef cattle raisers. Steers were weaned at 8 months of age and were assigned to either one of two feeding strategies: short-term or long-term feeding. The short-term group was fed until 26 months of age while the long-term group was fed until 32 months of age. Both treatment groups were fed with barley-based concentrates and whole-crop barley silage at 80:20 concentrate to roughage ratio. At the end of the feeding period, 8 animals from each treatment group were slaughtered and chilled for 24 hours. Strip loin samples were taken from the right side of the carcass. Each loin was divided into two portions, vacuum-packed and was assigned to two aging groups, 1-day or 10-day aging. Aging was done at 4^{o}C.

B. Fatty acid analysis and extraction

Direct transesterification of fatty acid followed the procedure developed by Rule (1997). Duplicate *Longissimus* tissue samples were prepared.

Gas chromatograph Agilent Technologies 6890N Network GC System equipped with Agilent Technologies 7683B Series Injector and Agilent Technologies 5973 Network Mass Selective Detector was used to separate and identify the fatty acid components of the samples. GC separation of components was carried out on a fused silica capillary column (30m x 0.25mm x 0.25 µm film thickness, Supelcowax 10). Split ratio was 100:1 and helium was used as the carrier gas. The inlet temperature was 250^{o}C and the oven temperature program was as follows: 50^{o}C for 1 min and was raised to 200^{o}C at a rate of 25^{o}C per minute. Thereafter, the temperature was further increased to 230^{o}C at 3^{o}C per min and held for 15 minutes. Detector temperature was 280^{o}C. Total running time was 35 minutes. Individual fatty acids were expressed as percentage of the total fatty acids detected as fatty acid methyl esters.

C. Sensory Evaluation

The sensory evaluation of the beef samples was done following the Korean barbecue protocols. Sensory evaluation was done by a consumer panel consisted of university students. A total of 48 sets of samples were evaluated in four sensory sessions i.e. 12 sets of samples per session. Each session had 12 panelists and each panelist evaluated 6 samples.

The beef samples allotted for evaluation were thawed 30 minutes before the scheduled sensory session. The vacuum-packed meat were opened only when the samples are about to be cooked. The meat strips were cooked to medium doneness following the Korean barbecue procedure. Cooking temperature ranged from 250–260^{o}C. The cooked samples were immediately dispensed on individual plates and served to the panelists. Sensory evaluation forms, a glass of distilled drinking water, salt-free crackers, knife and fork were provided to the panelists.

D. Statistical analysis

The main effects of the length of feeding and aging period and length of feeding x aging period interaction were analyzed using SAS PROC GLM (SAS Institute, Cary, NC). The length of feeding x aging period interaction was not significant for the traits that were measured hence, only the least square means of the two main effects were presented.

III. RESULTS AND DISCUSSION

A. Fatty acid composition

There were no significant differences on the individual fatty acid component of beef from the two feeding groups except for C20:0 (Table 1). The difference in the concentration of C20:0 is small as to be of biological importance. Strip loin aged for one day or 10 days had similar fatty acid composition. Some studies have also found that the length of feeding had very small influence on the fatty acid composition of beef. The SFA and MUFA of Longissimus muscle of crossbred steers changed little with time on feed. It was reported that feeding intensity had greater influence on the intramuscular fatty acid composition of Simmental bulls compared to the length of feeding. In contrast, several studies have demonstrated that time on feed affects the fatty acid composition of beef. The fatty acid profile was altered in steers grazed on Bermuda grass for 150 days before finishing with a high-concentrate diet for 90 days [1]. An increase in MUFA and a decrease in PUFA of beef from grass-fed steers then fed with high concentrate diets from 0 to 196 days was observed [8]. Differences in fatty acid profile were also observed in cull beef cows fed concentrate diets for 42 days. In most of these studies, it was noted that significant changes in the fatty acid profile occurred during a change in the type of diet given to the animal i.e. from a high forage diet to a high concentrate diet. It was pointed out that feeding regime can influence the lipids in red meat due to the fatty acid composition of the feed [14]. In the current experiment, the steers were fed whole crop barley silage and barley-based concentrate for the entire duration of feeding and this probably explains the similarity in the fatty acid profile of the resulting meat from the two feeding periods. There never was any change in the fatty acid profile of the diet during the experimental period hence the fatty acid profile of the meat was not substantially altered.

Although we observed that there was an increase in fatness in carcasses from steers in the long term-fed group, the fatty acid composition remained relatively the same in the two treatment groups. It was noted that increased unsaturation of fatty acids in meat was associated with marbling. However, as steers grow and fatten, precise metabolic events dictate the nature of the fatty acids and unless synthesis, elongation and desaturation are markedly altered, production of different fatty acid profile in not likely to occur. Differences in genetics and environment (i.e. feeding system) that alter fatty acid metabolism in the animal may cause some differences in the fatty acid profile. For instance, it has been shown that barley and wheat produce fats with a different character such that wheat-fed steers had more C14:0, C16:0 and C16:1 and less C18:0 than did barley-fed animals [6]. There was a trend for higher concentrations of the saturated fatty acids in beef of barley-fed steers compared to corn-fed steers. The predominant fatty acids that were obtained in the present study include palmitic (C16:0), stearic (C18:0) and oleic (C18:1).

It was also observed that oleic acid (C18:1) constituted 90% of the total MUFA. The PUFA to SFA ratio (0.07 – 0.08) values were lower than the PUFA:SFA (0.21 – 0.34) obtained in Hereford x Friesian bulls fed barley straw and concentrates containing barley and soya bean meal [9]. This can be attributed to differences in the breed of cattle and the composition of diets. The high n-6:n-3 ratio seemingly indicates that the n-3 content of whole-crop barley silage is low such that the resulting meat had low n-3 concentration. However, this could not be substantiated since the fatty acid profile of the treatment diet was not determined. The high n-6:n-3 ratio may also be attributed to the high proportion of barley-based concentrate diet relative to the whole crop barley silage given to the steers. Concentrates contain more linoleic acid (C18:2n-6) whereas forage has more linolenic acid (C18:3n-3) [14].

B. Sensory quality

Feeding system significantly influenced juiciness (P = 0.009) with the beef from the long term-fed group having higher juiciness scores than the short term-fed group (Table 2). The difference in juiciness could be due to the higher intramuscular fat content of the strip loin from long term fed-cattle. Juiciness is the trait that is most affected by increasing levels of marbling fat and this was ascribed to the greater retention of water in meat during cooking. On the contrary, it has been reported that juiciness was not affected by the time on feed [15].

It was observed that the length of feeding had no significant influence on the sensory scores on tenderness, flavor, overall acceptability and rating based on consumer panel assessment. Trained panel assessment revealed that increased time on high-concentrate feed improved flavor intensity and overall palatability of beef [1, 2, 10]. This was attributed to the positive relationship between intramuscular fat and flavor intensity [1]. In the present experiment, the high intramuscular fat content of loin from the long term-fed group did not influence the tenderness, flavor, overall acceptability and rating. It could have been that the optimum palatability traits of the loin were attained at 26 months of age and that no further improvement occurred beyond 26 months. A study has demonstrated that extending the feeding period of 16 month old Angus x Hereford steers beyond 112 d did not enhance the palatability characteristics of beef [8]. However, it was reported that juiciness and flavor intensity were not influenced by the time on concentrate feed [15].

Aging significantly improved tenderness (P = 0.005), overall acceptability (P = 0.018) and rating (P = 0.015) of the strip loin. The D10 steaks had higher tenderness, overall acceptability and rating scores than the D1 steaks indicating the positive influence of tenderness on the acceptability and rating of beef. This supports the survey report that most consumers identified tenderness as the attribute that contributes most to eating satisfaction [12]. The significant increase in tenderness is as expected since a number of researches have demonstrated that the greatest improvement in tenderness occurred during the first few days of aging [3, 17]. Aging had no significant effects on flavor and overall acceptability of steaks from calf-finished or yearling-finished cattle [4]. This observation supports the current findings. It could have been that 10 days of aging is short for the flavor to change. A study has demonstrated that during aging there is a gradual decline in beef flavor and a significant increase in the undesirable bitter compounds after 10 days. In addition, the almost similar fatty acid profile of strip loin from the long term-fed and short term-fed cattle could be attributed to the lack of difference in the flavor of the beef samples. Fatty acid composition and aromatic, water-soluble compounds that are stored in lipid depot influence flavor [16].

IV. CONCLUSION

The length of feeding whole-crop barley silage and barley-based concentrates did not alter the fatty acid composition of the Hanwoo *longissimus* muscle. Except for juiciness, other sensory traits such as tenderness and flavor were not improved by additional 6 months on the diet.

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Table 1. Least square means (DF=1/28) of fatty acid (% of total fatty acid) of *longissimus* muscle of Hanwoo subjected to different feeding systems and aging periods

Parameters	Feeding System		Aging		Ave.	F ratio	
	Short	Long	D1	D10	S. E.	Feeding	Aging
C14:0	3.87	3.68	3.93	3.63	0.23	0.33	0.84
C15:0	0.32	0.35	0.37	0.31	0.03	0.41	1.40
C16:0	26.19	25.13	25.20	26.12	0.43	2.95	2.21
C16:1n-7	5.15	5.05	5.12	5.08	0.23	0.11	0.01
C18:0	12.70	13.21	13.32	12.60	0.62	0.35	0.69
C18:1n-9	47.69	48.14	47.62	48.22	0.79	0.17	0.29
C18:2n-6	2.50	2.66	2.47	2.69	0.26	0.18	0.35
C18:3n-3	0.14	0.10	0.17	0.07	0.07	0.15	1.01
C20:0	0.03	0.09	0.07	0.05	0.02	4.72*	0.12
C20:1n-9	0.43	0.35	0.39	0.39	0.04	1.99	0.00
C20:3n-3	0.15	0.12	0.13	0.13	0.03	0.48	0.01
C20:4n-6	0.35	0.38	0.37	0.36	0.06	0.14	0.01
SFA[a]	43.11	42.48	42.88	42.70	0.83	0.28	0.02
MUFA[b]	53.27	53.54	53.12	53.69	0.81	0.06	0.25
PUFA[c]	3.13	3.26	3.14	3.25	0.29	0.09	0.07
PUFA:SFA[d]	0.07	0.08	0.07	0.08	0.01	0.15	0.08
UFA[e]	56.40	56.79	56.26	56.93	0.85	0.11	0.32
UFA:SFA[f]	1.32	1.35	1.33	1.34	0.04	0.34	0.07
n-6[g]	2.85	3.04	2.84	3.05	0.28	0.23	0.29
n-3[h]	0.28	0.21	0.30	0.20	0.07	0.44	1.05
n-6:n-3[i]	12.15	14.17	11.97	14.35	2.16	0.44	0.61

[a]SFA = C14:0 + C15:0 + C16:0 + C18:0 + C20:0
[b]MUFA = C16:1n-7 + C18:1n-9 + C20:1n-9
[c]PUFA = C18:2n-6 + C18:3n-3 + C20:3n-3 + C20:4n-6
[d]PUFA:SFA = PUFA/SFA
[e]UFA = MUFA + PUFA
[f]UFA:SFA = UFA / SFA
[g]n-6 = C18:2n-6 + C20:4n-6
[h]n-3 = C18:3n-3 + C20:3n-3
[i]n-6:n:3 = n-6 / n-3
*P<0.05, **P<0.01, ***P<0.00

Table 2. Least square means (DF=1/28) of the sensory attributes of *longissimus* muscle of Hanwoo subjected to different feeding systems and subjected to different aging periods

Traits	Feeding System		Aging		Ave.	F ratio	
	Short	Long	D1	D10	S.E.	Feeding	Aging
Tenderness[a]	57.20	59.53	51.78	64.94	3.06	0.29	9.25**
Juiciness[b]	64.71	70.72	67.49	67.93	1.51	7.90**	0.04
Flavor[c]	61.11	62.29	61.26	62.14	2.25	0.14	0.08
Overall Acceptability[d]	56.88	62.32	55.03	64.18	2.58	2.22	6.29*
Rating[e]	1.99	2.28	1.94	2.33	0.11	3.93	6.70*

[a]Tenderness rating: 0 (not tender) to 100 (very tender)
[b]Juiciness rating: 0 (not juicy) to 100 (very juicy)
[c]Flavor rating: 0 (dislike extremely) to 100 (like extremely)
[d]Overall acceptability: 0 (dislike extremely) to 100 (like extremely)
[e]Rating: 1- unsatisfactory; 2 – good everyday quality; 3 – better than everyday quality; 4 - premium quality
*P<0.05, **P<0.01, ***P<0.001