EFECTS OF FULL-FAT SOYBEAN DIETS ON PERFORMANCE, CARCASS CHARACTERISTICS AND FATTY ACID COMPOSITION OF HANWOO STEERS

Sung Il Kim[1,*], Young Min Jo[2], Keun Ki Jung[3], Jin Yeoul Kim[2], Chang Bon Choi[1]

[1]Yeungnam University, Gyeongsan, 38541, Korea

[2]Gunwi Livestock Cooperative Federation, Gunwi 39015, Korea,

[3] Moksan Hanwoo Research Institute, Gyeongsan , 38507, Korea

[*]Corresponding author email: ymin38317@hanmail.net

Abstract- Effect of dietary full-fat soybean on performance and carcass characteristics of Hanwoo steers was investigated. Thirty steers (653±52.96kg) were allotted to control and full-fat soybean groups with a 210-day comparative feedlot trial and fed either the basal finishing diet (control) or control plus 5 % full-fat soybean using Calan gates for individual intake measurement. There was no difference in BW, feed intake, carcass weight, back-fat thickness, loin muscle area and meat color between groups. Average daily gain was greater ($p<0.05$) soybean group than control. Steers fed soybean showed a lower feed conversion ratio than control. Marbling score of soybean group was greater ($p<0.05$) than that of control.

Supplementary full-fat soybean increased ($p<0.05$) the crude fat level but decreased ($p<0.05$) the crude protein content in LD muscle. Full-fat soybean increased ($p<0.05$) the total unsaturated fatty acids, including the levels of oleic acid, linoleic acid and linolenic acid, but consequently decreased ($p<0.05$) the total saturated fatty acids. Conjugated linoleic acid and its major precursor trans-vaccenic acid levels were significantly increased by soybean supplementation. Our results demonstrate that full-fat soybeans may offer a better way to produce a healthier beef with increased unsaturated fatty acids.

Key words- full-fat soybean, linoleic acid, conjugated linoleic acid, Hanwoo steers

I. INTRODUCTION

Lately, consumer's preference for meat product has been focusing on the healthiness, such as health-related functionality, rather than the meat qualityitself in terms of marbling score (Kim et al., 2013). Of its beneficial effects on preventing the risk of metabolic disorders, including diabetes, arteriosclerosis and cancer, conjugated linoleic acid (CLA) has actively been subject to beef product research (Whigham et al., 2000). The CLA is found predominantly in milk and meat of ruminants and originated from the process of microbial hydrogenation of either $C_{18:2}$ (linoleic acid) or $C_{18:3}$ (linolenic acid) into $C_{18:0}$ (stearic acid; Fritsche et al., 2000). The total amount of CLA in animal products varies greatly depending on what animals ate: supplementation of ruminant rations with vegetable oils rich in linoleic and linolenic acids increases the CLA content in their meat (Dhiman et al., 2005). Soybean, the most widely used feed ingredient, is rich in protein and fat, thereby provides the essential amino acids and fatty acids, especially unsaturated fatty acids (Whang, 1990). Enhanced ruminal CLA content was observed by supplementation of either linseed oil or fish oil (Enser et al., 1999). Feeding cattle with high-oil corn (McGuire et al., 1998) or soybean oil (Beaulieu et al., 2000) had no effect on CLA production. Madron et al. (2002) showed that administration of extruded full-fat soybean increases the CLA content in fat tissues of steers. Therefore, we hypothesized that full-fat soybean, which is rich in unsaturated fatty acids and high quality amino acids, will increase the CLA content in Hanwoo beef. The objective of this study was to evaluate the effect of full-fat soybean diet on performance, carcass characteristics and CLA content of loin muscle of Hanwoo steers.

II. MATERIALS AND METHODS

1. **Animals, diets and management**

The experiment was conducted at a local cattle experiment farm in Gyeongbuk, Korea.

Experimental animals were handled according to the guideline of the National Institute of Animal Science, Korea.Thirty Hanwoo steers (BW 653 ± 52.96kg, Age 23.7 ± 0.2mo.) were stratified by BW and age, and randomly assigned to control or full-fat soybean diet group. Steers were fedusing Calan gates for individual intake measurement either the basal corn-based finishing diet (control) or control diet plus 5% full-fat soybean, which was replaced with 3% soybean meal and 2% coconut meal. Steers were then kept in a 4.5 ×9.0m pen (5 animals per pen) under treatment for a period of 210 days excluding 15 days of adjustment period. All animals fed twice per day and had free access to water. Feed intake was recorded daily and animals were weighed monthly. Animal diets were formulated following Korean Feeding Standard (National Institute of Animal Science, 2012).

3. Fatty acid composition analysis by gas chromatography

Fatty acid methyl esters (FAME)were prepared as modified methods described by Lepage and Roy (1986) and Choi et al. (2015).

4. Statistical analysis

A variance analysis was carried out in accordance with the general linear model (GLM). Data are represented as the least squares mean ± SE and compared with Student's *t*-test of SAS (2002). Statistical significance was established at P<0.05.

Ⅲ. RESULTS AND DISCUSSION

1. Carcass characteristics

Carcass weight, backfat thickness, LD muscle area, marbling score, and meat color of Hanwoo steers are shown in Table 1. Steers fed a full-fat soybean supplemented diet tended to have greater (P=0.06) carcass weight than control group. There was no difference in backfat thickness, LD area and meat color between control and treatment group. Feed ingredients included in diets as well as feeding strategy during the fattening period are determinants of economic traits, including the backfat thickness, LD area and marbling score in steers (May et al., 1992). Felton and Kerley (2004) showed an increase in marbling score of steers supplemented with soybean diet. Concomitant to these results, our current and previous studies (Kim et al., 2013) showed that feeding roasted soybeans or full-fat soybean during fattening period increased (p<0.05) the marbling score, suggesting that dietary soybean treatment has a beneficial effect on meat quality grade in Hanwoo steers.

Table 1. Carcass yield and quality grades of Hanwoo steers fed full-fat soybean supplemented diets.

Items	Control	Full-fat soybean[1)]	T-test
Cold carcass weight, kg	448.48±30.41[2)]	469.02±32.60	0.0621
Yield traits:			
Backfat thickness, mm	14.27±6.82	16.64±5.37	0.1749
M, longissimusdorci area, cm^2	92.93±11.39	98.73±9.06	0.2255
Yield index	62.44±5.09	63.14±4.76	0.6032
Quality traits:			
Marbling score[3)]	5.98±1.22	7.01±1.43	0.0429
Meat color[4)]	4.70±1.06	4.96±0.36	0.8734
Fat color[5)]	2.93±0.26	2.93±0.27	0.5987
Texture[6)]	1.00±0.00	1.07±0.27	0.1632
Maturity[7)]	2.00±0.00	2.00±0.00	1.0000

[1)] Contained 5% of fed full-fat soybean in diet.
[2)] Mean ± SD.
[3)] 9 = the most abundant, 1 = devoid.
[4)] 7 =dark red, 1 = bright.
[5)] 7 = yellowish, 1 = white.
[6)] 3 = Coarse, 1 = fine.
[7)] 9 = mature, 1 = youthful.

2. Physiocochemical characteristics of the carcass

Moisture level was not significantly different between control and full-fat soybean group showing 63.73% and 61.05%, respectively. Crude fat content in full-fat soybean group (19.01%) was greater (p<0.05) than that in control (15.73%). Crude protein content of full-fat soybean group (13.15%) was lower than that of control group (18.77%). The overall range of measured CIE values, including L (lightness), b (yellowness), and h (color), was not different between experimental groups. The amount and nutrient composition of diet affects the absorption rate and subsequent partitioning of nutrients toward body fat or protein (Cameron et al., 1994). Meat quality grade is increased with increased crude fat contents, which is negatively correlated with moisture content (Luchak et al., 2004; Nelson et al., 2004). In agreement with these data showing an association of feed nutrients in meat quality constituent, supplemental full-fat soybean somehow changed the body composition of Hanwoo steers towards having more fat content in the current study. Further study will be necessary to specify the mechanisms by which feeding full-fat soybean modulates the nutrient conversion (or energy repartitioning) in muscle and fat biosynthesis.

3. Fatty acid composition of *M. Longissimus dorsi*

Supplementation of 5% full-fat soybean decreased (p<0.05) the total saturated fatty acids (SFA) level, but increased the total unsaturated fatty acids (UFA) level in LD muscle of Hanwoo steers (Table 2). More specifically, full-fat soybean supplementation decreased (P<0.05) palmitic acid ($C_{16:0}$) among SFA, and increased (P<0.05)the oleic acid ($C_{18:1}$), linoleic acid ($C_{18:2}$) and linolenic acid ($C_{18:3}$) among UFA. Consumers nowadays aware the impact of saturated fat consumption on their health. This concern results in closer scrutiny of the fatty acid composition of ruminant products.Level of SFA is mainly affected by the palmitic acid ($C_{16:0}$) and stearic acid ($C_{18:0}$) and UFA concentration is related to the oleic acid ($C_{18:1}$) content in beef (May et al., 1992). Lee et al. (2003) reported a result obtained from the rumen dry matter and fatty acid degradability experiment that supplementary full-fat soybean increased (p<0.05) oleic acid level. Later, Felton and Kerley (2004) reported that 16% supplemental soybean decreased SFA level in whole body fat of steers. Plant oil is not a common supplement in ruminant feed since large amount of polyunsaturated fatty acids (PUFA) in this oil can be toxic to rumen microbes, which possibly lower the ruminal fermentation and animal productivity. An alternative approach used in our current study is to feed steers with supplemental full-fat soybean containing high level of poly UFA (Table 4), which allow the oil source to become gradually available for microbial fermentation, thus minimize the adverse effects on microbial growth. This approach markedly increased the UFA, especially the oleic acid and mono UFA, in LD muscle of Hanwoo steers. Therefore, supplementation of dietary full-fat soybean could be a better way to modulate the nutritional profile, especially the fatty acid composition, in beef products.

Ritzenthaler et al. (2001) reported that about 30% of consumer’s intake of CLA is originated from beef products. The concentration of CLA in milk and meat is affected by animal’s breed, age, diet and feeding regime(Griinari and Bauman, 1999). Biomedical studies with animal models demonstrated that an increase in the CLA content of milk and meat has the potential to raise the nutritive and therapeutic values of dairy and beef products (Whigham et al., 2000). Administration of full-fat soybean markedly increased the CLA in milk fat, but only few studies investigated these effects on beef products. Therefore, our main objective was to examine the effects of dietary supplementation of full-fat soybeans on the CLA level in LD muscle of Hanwoo steers. When compared with control diet, full-fat soybean diet increased (p<0.05) the level of CLA and trans vacceinc acid (TVA) level in LD muscle of Hanwoo steers (Table 3). The cis-9 and trans-11 *isomer* is the principal dietary form of *CLA*(about 72%), *but the concentration of these isomers in beef vary depending on the diets fed to steers (Frische et al., 2000). Feeding 3~6% roasted soybean increased the CLA content in the loin beef (Mir et al., 2002). Vegetable oils, such as sunflower oil and linseed oil, as well as flaxseed and soybean treatment decrease marbling but increase CLA content in beef (Wachira et al., 2002).*The cis-9 CLA and trans-11 TVA levels in soybean supplement group were about 0.21% and 0.51%, respectively, greater than those in control. The trans-9 TVA was also detected but data not shown here due to its negligible amount. Full fat soybean supplementation provides polyunsaturated fatty acids, especially linoleic acid and linolenic acid, which are key substrates in rumen biohydrogenation (Dhiman et al., 2005). This would, in turn, increase ruminal production of cis-9 CLA and trans-11 CLA as well as TVA, which is converted into CLA by Δ^9desaturase (Bauman et al., 1999). TVA, which is a major precursor of CLA, is responsible for about 78% of CLA production in milk (Corl et al., 2001).

Concomitant to these data, our results also showed that full fat soybean increased the level of CLA as well as TVA in LD muscle of Hanwoo steers.

Since consumer and end-use preference for meat is changing, feeding strategy nowadays is to modify fatty acid composition of meat. In this regard, dietary full fat Soybeans will offer an opportunity for beef producers not only to improve a healthiness of meat but also to lower the feed costs without any detrimental effect on productivity.

In conclusion, this study investigated the effect of dietary full-fat soybean supplementation on performance and carcass characteristics, especially the fatty acid composition of loin muscle, in Hanwoo steers. Thirty Hanwoo steers (average BW 653.53±52.95kg, age 23.7±0.2mo.) were allotted randomly to 2 groups of 15 steers based on initial BW and fed either a basal finishing diet or the basal diet supplemented with 5% full fat soybean. Full-fat soybean diet group showed a greater (p<0.05) ADG but lower feed conversion ratio by 23.4% than control. Marbling score was significantly improved in full-fat soybean treatment group. Interestingly, supplementation of full-fat soybean decreased (p<0.05) SFA, but increased (p<0.05) UFA with significant increase in CLA and TVA contents. Taken together, administration of full-fat soybean has a beneficial effects on ADG and formation of healthier fatty acid (unsaturated fatty acids) composition in loin muscle of Hanwoo steers.

Table 2. Fatty acid composition of M. *longissimusdorsi* of Hanwoo steers fed full-fat soybean supplemented diets.

Items	Control	Full-fat soybean[1)]	T-test
		%	
$C_{12:0}$	0.10 ± 0.03[2)]	0.12 ± 0.02	0.8451
$C_{14:0}$	3.81 ± 0.80	3.22 ± 0.69	0.1247
$C_{14:1}$	0.35 ± 0.04	0.20 ± 0.04	0.0721
$C_{15:0}$	1.37 ± 0.28	1.26 ± 0.36	0.2146
$C_{15:1}$	0.15 ± 0.01	0.08 ± 0.01	0.0612
$C_{16:0}$	26.97 ± 2.21	21.69 ± 1.73	0.0458
$C_{16:1}$	6.74 ± 1.18	6.42 ± 0.92	0.7587
$C_{17:0}$	0.18 ± 0.03	0.16 ± 0.04	0.3257
$C_{18:0}$	9.10 ± 0.73	9.89 ± 0.68	0.0913
$C_{18:1}$	48.29 ± 3.39	51.03 ± 2.98	0.0420
$C_{18:2}$	1.68 ± 0.37	1.98 ± 0.43	0.0321
$C_{18:3}$	0.27 ± 0.13	0.30 ± 0.12	0.0265
$C_{20:0}$	0.44 ± 0.03	0.42 ± 0.02	0.6528
SFA[3)]	41.97 ± 2.32	36.76 ± 2.68	0.0115
UFA[4)]	57.48 ± 2.76	60.01 ± 2.09	0.0314
MUFA[5)]	55.53 ± 2.37	57.73 ± 2.53	0.0645
PUFA[6)]	1.95 ± 0.21	2.28 ± 0.39	0.1284
U/S[7)]	1.37	1.63	0.0457

1) Contained 5% of fed full-fat soybean in diet.
2) Mean ± SD.
3) Saturated fatty acid.
4) Unsaturated fatty acid.
5) Monounsaturated fatty acid.
6) Polyunsaturated fatty acid.
7) Unsaturated fatty acid/Saturated fatty acid.

Table 3. Composition conjugated linoleic acid (CLA) and transvaccenicaicd (TVA) of Hanwoo steers fed full-fat soybean supplemented diets

Items	Control	Full-fat soybea	T-test
		c9, t11 CLA, %	
M. longssimusdo	0.22±0.06	0.43±0.07	0.0223
		t11 TVA, %	
M. longssimusdo	1.31±0.27	1.82±0.23	0.0441

1) Contained 5% of fed full-fat soybean in diet.

REFERENCES

Paper:

1. Beaulieu AD, Drackley JK, Merchen NR, Falkenstein EL. Concentrations of conjugated linoleic acid in beef carcasses are not increased by supplementing a high-corndiet with 5.0% soybean oil. J Anim Sci 2000; 78:285.

2. Choi SH, Park SK, Johnson BJ, Chung KY, Choi CW, Kim KH, Kim WY, Smith SB. AMPKα, C/EBPβ, CPT1β, GPR43, PPARγ, and SCD gene expression in single- and co-cultured bovine satellite cells and intramuscular preadipocytes treated with palmitic, stearic, oleic, and linoleic acid. Asian Australas J Anim Sci 2015; 28: 411-419.

3. Enser M, Scollan ND, Choi NJ, Kurt E, Hallett K, Wood JD. Effect of dietary lipid on the content of conjugated linoleic acid (CLA) in beef muscle. J Anim Sci 1999; 69: 143-146.

4. Kim SI, Cho BR, Choi CB. Effects of sesame meal on growth performances and fatty acid composition free amino acid contents, and panel tests of loin of Hanwoo steers. J Anim Sci Technol2013; 55: 451-460.