African Journal of Agricultural Research Vol. 7(30), pp. 4331-4336, 7 August, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR12.1127
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Effects of dietary soybean curd residue on the growth performance and carcass characteristics in Hanwoo (*Bos taurus coreanae*) steer

Kyoung Hoon Kim[1], Sung Jin Kim[2], Byong Tae Jeon[2], Dong Hyun Kim[2], Mi Rae Oh[2], Pyo Jam Park[2], Hyuk Jung Kweon[3], Baek Yeong Oh[4], Sun Jin Hur[2] and Sang Ho Moon[2]*

[1]National Institute of Animal Science, RDA, Suwon, 441-706, Korea.
[2]School of Food Bio Science, Korea Nokyoung Research Center, Konkuk University, Chungju, 380-701, Korea.
[3]Department of Family Medicine, School of Medicine, Konkuk University, Chungju, 380-701, Korea.
[4]Icheon Agricultural Technology Center, Icheon, 467-801, Korea.

Accepted 17 July, 2012

This study was conducted to determine the effect of dietary soybean curd residue (SCR) on the growth performance and carcass characteristics in Korean native cattle, Hanwoo steer (*Bos taurus coreanae*). A total of 15 cattle (8 month old and averaging 238.5±12.4 kg in weight) were divided into three dietary groups and then fed a diet containing 0 (T1, control), 25 (T2) and 35% SCR (T3) for 22 months. Meat (*M. longissimus dorsi*) grade were estimated by the Korean carcass grading system. In growth performance, dry matter intake (DMI) and average daily gain (ADG) were significantly higher in SCR groups (T2 and T3) than T1 group in final fattening period. Feed efficiency of T3 group was higher than other groups for all feeding periods, and carcass weight and marbling score of T3 were higher than other dietary groups. Crude fat content of meat was higher in SCR groups than T1 group. Consequently, dietary SCR could improve growth rate of cattle without any meat quality deterioration. These results may be closely related with the increase of DMI and ADG by dietary SCR.

Key words: *Longissimus dorsi* muscle, dry matter intake, feed conversion, marbling score.

INTRODUCTION

Soybean has been used as a source of high-quality protein and energy for humans worldwide. This nutritious crop has also been popular as a tonic and restorative food because of its high content of isoflavone, a compound whose chemical structure is similar to that of estrogen (Kim and Kang, 2009). For an efficient use of soybean, a variety of soybean products (fermented and processed products) have been produced. Soybean curd residue (SCR) is a by-product which is produced during the production of tofu or soymilk from soybeans. According to Kwak and Yoon (2003), SCR is a valuable source of protein, which consists of 17.8% dry matter, 30.5% crude protein, 10.9% crude fat and 44.9% non-digestible fiber. However, this by-product has a lower content of lysine compared to soybean meal, but has an 88% pepsin digestibility of proteins (Kwak and Yoon, 2003). In a previous study (Moon et al., 1999), no significant difference in antler productivity of Sika deer (*Cervus nippon*) was observed when fermented SCR was fed. However, there were some positive results in a weight gain of deer and circumference of antler. In another study, Abe (2001) reported that dry matter intake (DMI), daily gain, carcass weight and marbling score (BMS) of loin eye was higher for the total mixed ration (TMR) feeding group with SCR than for control group in Japanese black beef cattle. Soybean curd residue has been widely used as a feed for Korean beef cattle,

*Corresponding author. E-mail: moon0204@kku.ac.kr. Tel: 82-43-840-3527. Fax: 82-43-851-4169.

Table 1. Formula of experimental diets.

Item	T1[4] (% FM[5])			T2 (% FM[5])			T3 (% FM[5])		
	GS[1]	EF[2]	LF[3]	GS	EF	LF	GS	EF	LF
Premix[6]	1	0.5	0.3	1	0.5	0.3	1	0.5	0.3
Commercial concentrates	28.9	23.7	14	26	20	14	24	23.8	15
Corn grain	10	21.5	34.4	8.7	17.8	33	12.7	17.9	33
Beet pulp	2.5	2	1	1	2	2	0	0	0
Brewer's grain wet	19	15	14	4	7	8	0	0	0
Whole cottonseed	0	0	3.7	0	4	3	0	0	2.4
Alfalfa	1.3	0	0	0	0	0	0	0	0
Tall fescue	16.5	12	7	18.5	12	7	18.5	12	7
Water	12.5	16	16	7	7	12	6	8	15
Molasses	2.5	2.5	2.5	2.5	2.5	2.5	2	2.5	2.5
Salt	0.1	0.1	0	0.1	0.1	0	0.1	0.1	0
Limestone	0.2	0.2	0	0.2	0.2	0	0.2	0.2	0
Corn fodder pellet	2.5	2.5	2.5	3	4	3.7	2.5	7	6
Tallow	0	0	0.6	0	0	0.5	0	0	0.8
Soybean curd residue	0	0	0	25	20	10	30	25	15
Probiotics	3	4	4	3	3	4	3	3	3
Total	100	100	100	100	100	100	100	100	100

[1]Growing stage; [2]early fattening stage; [3]late fattening stage; [4]T1: 0% soybean curd residue. T2: 25% soybean curd residue, T3: 35% soybean curd residue; [5]fresh matter; [6]a kilogram of the premix (Grobic-DC, Bayer HealthCare, Leverkusen, Germany) provided the following nutrients: vitamin A, 2,650,000 IU; vitamin D3, 530,000 IU; vitamin E, 1050 IU; niacin, 10,000 mg; Mn, 4400 mg; Fe, 13,200 mg; I, 440 mg; Co, 440 mg.

Hanwoo (*Bos taurus coreanae*), especially when tofu factories are located nearby. Despite its high nutritive value, it is hard to find scientific research data on SCR utilization and its impact on physiological characteristics of Hanwoo. Therefore, it will be necessary to determine proper utilization method of SCR and to evaluate its feeding effectiveness, and it was hypothesized that the feeding system with SCR in Hanwoo steer would be associated with some beneficial changes in growth indices and meat technological characteristics. To verify this hypothesis, a control diet and experimental diets supplemented with two doses of SCR were applied for 22 months to Hanwoo steer.

MATERIALS AND METHODS

Animals and samples

Fifteen castrated Hanwoo steer (8-month-old, 238.5±12.4 kg) were raised for 22 months (6 months of growing stage, 8 months of early fattening stage, 8 months of late fattening stage) at commercial cattle farm (Saebom, Icheon, Korea). All animal-based procedures were approved by the Institutional Animal Care and Use Committee at Konkuk University (KU10064). Steer were divided into three dietary groups (n=5) and five steer of each group was arranged in a 64 m^2-wide stalls respectively, in accordance with Animal Protection and Welfare Standards. Three groups were initially fed a TMR diet containing 0 (T1, control), 25 (T1) and 35% of SCR (T2) in growing stage. However, the formulation of SCR in TMR was gradually changed with progress of fattening stage in T2 and T3 groups; steers in T2 group were less fed with ratio of 20 and 10% SCR in early and late fattening stages, respectively, and steers in T3 group were less fed with ratios of 25 and 15% SCR in early and late fattening stages, respectively. The formulation and chemical composition of experimental diets at each stage is shown in Tables 1 and 2.

The meat grade system in Korea, the beef quality grades, in addition to color of lean, firmness and texture of lean, maturity and color of fat, are based on the amount of marbling present in the exposed *longissimus dorsi* muscle at the 13th rib interface [National Livestock Cooperatives Federation (NLCF), 2010]. A marbling score of beef marbling standard (BMS, 7 = very abundant; 1 = devoid) No. 7 or 6 is marbling degree for grade 1^{++}; BMS No. 5 or 4 is the requirement for grade 1; BMS No. 3 or 2 comprise grade 2; and BMS No. 1 is the marbling degree for grade 3. Quality grade 1^{++} is the highest or most desirable grade and grade 3 is the lowest degree of quality. Yield grades were determined on the basis of estimated retail cut percentage, which was a function of back fat thickness, ribeye area and cold carcass weight (A = higher than standard; B = standard; C = lower than standard). After the meat grade was judged, the *M. longissimus dorsi* (from the 7th thoracic vertebrae to the last lumbar vertebrae, LD) were removed from the right side of the carcass at 24 h postmortem in commercial slaughter house. It was dissected to separate lean meat, fat and connective tissue and then transferred to the laboratory. SCR was supplied from tofu manufacturing factory near the experimental farm at every two days interval.

Data collection

Weight gain and feed conversion

Weight gain, DMI and feed conversion were measured by two

Table 2. Chemical composition of experimental diets.

Items	T1[7]			T2			T3		
	GS[1]	EF[2]	LF[3]	GS	EF	LF	GS	EF	LF
Dry matter	64.15	63.12	63.61	61.99	63.28	64.35	62.17	63.60	64.07
		% DM[8]			% DM[8]			% DM[8]	
TDN[4]	70.06	74.26	81.27	70.04	74.43	81.13	70.55	74.25	81.48
Crude protein	15.44	14.60	12.71	15.48	14.77	12.35	15.56	14.62	12.63
Crude fiber	17.72	14.52	11.26	18.50	15.96	11.59	17.88	16.01	12.18
NDF[5]	43.54	37.60	29.33	43.54	38.56	29.14	42.44	38.75	30.33
ADF[6]	23.89	19.61	15.07	24.18	21.36	15.50	23.16	21.08	15.95
Crude fat	5.10	4.97	6.18	5.41	5.85	5.93	5.50	5.28	6.36
Ash	8.24	6.85	4.85	8.05	6.74	4.69	7.81	6.68	4.80
Ca	0.80	0.58	0.35	0.81	0.60	0.37	0.79	0.61	0.37
P	0.60	0.56	0.46	0.60	0.54	0.44	0.62	0.54	0.46

[1]Growing stage, [2]early fattening stage, [3]late fattening stage, [4]total digestible nutrition, [5]neutral detergent fiber, [6]acid detergent fiber, [7]T1: 0% soybean curd residue, T2: 25% soybean curd residue, T3: 35% soybean curd residue, [8]dry matter.

months interval throughout the test period. Weight changes were determined with balance (CAS balance) for cattle every two months. DMI was measured by examining feed supply quantities and remains in the morning and in the afternoon for 7 days every two months. Feed conversion was calculated by dividing weight gain with DMI during experimental period.

Chemical composition of meat sample

The dry matter, crude protein, crude fat and crude ash contents of meat samples were measured in accordance with the AOAC (1990) method. Carbohydrate was analyzed using the titrimetric method (FCC, 1981).

Statistical analysis

The main effects between groups were subjected to ANOVA using the general linear model procedure of SAS (2001). The Duncan's multiple-range test was used to compare the differences among means. Significance was declared at $P<0.05$.

RESULTS AND DISCUSSION

Weight gain and feed intake

The changes of body weight, average daily gain (ADG), DMI and feed conversion by dietary SCR in Hanwoo steer are shown in Table 3. At the end of early fattening period, the body weight of T1 (control) group was the highest (582±60.20 kg), whereas body weight was the highest (783±85.81 kg) in T3 group at the late fattening period (at the end of the test) with no significant difference.

In ADG, T3 group was the highest with 0.88±0.10 kg than other groups at the early fattening period, and also, T3 (0.62±0.07 kg) showed significantly higher ADG than T1 group (0.48±0.09 kg) ($p<0.05$) at the late fattening stage. Moreover, T3 group (0.78±0.06 kg) was significantly higher in ADG than the other dietary groups during the test periods. A previous study (Feng et al., 2007) reported that dietary fermented soybean meal improved the growth performance of piglets. Kim et al. (2005) also reported that pigs fed a diet with 50 g soybean meal fermented with A. *oryzae* had a greater ADG and gain/feed than the T1 group. Feng et al. (2007) suggested that the growth-promoting effects may be due mostly to the improvement of the nutritional value of soybean meal. Thus, the authors assume that the dietary SCR not only improved the nutrition value, but also improved the digestibility because digestibility of soybean was improved by fermentation (Vee and Schaefer, 1950). In general, fermentation of soybean may be associated with degradation of soybean globulines (Liener and Kakade, 1980; Feng et al., 2007). Therefore, nutrient utilization of soybean such as protein and energy may be improved, this is one of the reasons why dietary SCR improved ADG in beef cattle.

In the present study, DMI was significantly higher in T3 group at the late fattening period and whole test period compared with other dietary groups. As a result of this study, the authors found that dietary SCR improved ADG at the end of feeding periods. This result may be closely related with increase of DMI because DMI was significantly higher in both T2 (7.99±0.14 kg) and T3 group (8.11±0.15 kg) than T1 group (7.71±0.71 kg). In general, leguminous crops are better than graminaceous crops in terms of palatability and intake (Romney and Gill, 2000). This is because SCR has a subtle flavor and savory taste. Therefore, the authors assume that SCR can improve the palatability of feed, and the increase of palatability of feed may be the main reason why DMI was increased by dietary SCR. The ADG was higher in SCR dietary groups at the late fattening period and it was also closely related with increase of feed palatability.

Table 3. Effects of dietary soybean curd residue on body weight, average daily gain, dry matter intake and feed conversion in Hanwoo steers.

Items		T1[8]	T2	T3
Body weight (kg)	IB[1]	247.40±38.97	248.40±52.10	225.80±50.68
	EF[3]	582.80±60.20	577.00±62.52	576.20±73.34
	LF[4]	742.80±39.72	775.00±49.98	783.20±85.81
	Total gain	495.40±31.60	526.60±42.93	557.40±46.57
ADG[6] (kg)	GS[2]	0.91±0.14	0.98±0.09	1.01±0.25
	EF	0.87±0.17	0.81±0.03	0.88±0.10
	LF	0.48±0.09[b]	0.59±0.11[ab]	0.62±0.07[a]
	Whole[5]	0.69±0.04[b]	0.74±0.05[ab]	0.78±0.06[a]
DMI[7] (kg/animal/day)	GS	6.52±0.35	6.60±0.38	6.87±0.18
	EF	8.37±0.54	8.53±0.42	8.55±0.26
	L[3]	8.25±0.26[b]	8.85±0.27[a]	8.90±0.54[a]
	Whole	7.71±0.22[b]	7.99±0.14[a]	8.11±0.15[a]
Feed conversion (gain/feed, kg)	GS	7.35±1.27	6.80±0.72	7.16±1.72
	EF	9.76±0.88	10.49±0.39	9.80±0.97
	LF	17.88±3.49	15.51±2.96	14.61±1.76
	Whole	11.17±0.46	10.92±0.81	10.47±0.74

[1]Initial body weight, [2]growth stage, [3]early fattening stage, [4]late fattening stage, [5]whole period, [6]average daily gain, [7]dry matter intake. [8]T1: 0% soybean curd residue, T2: 25% soybean curd residue, T3: 35% soybean curd residue. Means±S.D.(n=5), [a-c] Means with the different superscripts in the same column are significantly different (P<0.05).

Table 4. Effect of dietary soybean curd residue on beef yield and quality in Hanwoo steers.

Items	T1[7]	T2	T3
Carcass weight (kg)	440.60±43.35	472.40±43.80	477.00±61.14
Yield Index (%)	63.34±3.67	60.77±4.76	64.99±3.83
Yield grade[1]	2.20±0.84	2.60±0.55	2.00±1.00
Back fat thickness (cm^2)	15.00±4.64	18.40±6.50	11.60±3.78
Longissimus muscle area (cm^2)	91.40±8.17	93.80±9.04	94.80±13.01
Mabling score[2]	7.00±1.87	6.80±1.64	7.60±1.52
Meat color[3]	5.00±0.00	4.80±0.45	5.00±0.00
Fat color[4]	3.00±0.00	3.00±0.00	2.80±0.45
Meat texture[5]	1.00±0.00	1.00±0.00	1.00±0.00
Meat maturity[6]	2.00±0.00	2.00±0.00	2.00±0.00

[1]Converted to a numeric grade: A=1, B=2, C=3, [2]9=most abundant, 1=devoid, [3]7=dark red, 1=bright, [4]7=yellowish, 1=white, [5]3=coarse, 1=fine, [6]9=mature, 1=youthful. [7]T1: 0% soybean curd residue, T2: 25% soybean curd residue, T3: 35% soybean curd residue. Means±S.D.(n=5).

Yield and quality grade of meat

Table 4 reveals that the yield and quality grades of meat were influenced by the dietary level of SCR. Carcass weight was the highest in T3 group (477±61.14 kg) and the lowest in T1 group (440±43.35 kg). In terms of yield index, T3 group (64.99±3.83) was the highest, followed by T1 group (63.34±3.67) and T2 group (60.77±4.76); however, T3 group was the lowest back fat thickness with 11.60±3.78 mm. In longissimus muscle area, dietary SCR groups (T2 and T3) were higher than T1 group. In meat quality grade, meat color, fat color, texture and maturity, there were no significantly differences among the dietary groups. These results indicate that dietary SCR could not influence meat quality grade although carcass weight or chemical composition was changed by dietary SCR in the

Table 5. Effect of dietary soybean curd residue on general chemical composition of meat produced in Hanwoo steers.

Items	T1[1] (DM%)	T2 (DM%)	T3 (DM%)
Crude protein	65.47± 9.70	64.82± 8.68	62.18± 9.61
Crude fat	37.56± 10.26	41.78± 8.98	45.92± 7.27
Total carbohydrate	8.71± 2.60	8.46± 1.65	11.28± 3.39
Ash	1.07± 0.01	1.15± 0.02	1.17± 0.01

[1]T1: 0% soybean curd residue, T2: 25% soybean curd residue, T3: 35% soybean curd residue. Means±SD (n=5).

present study. In general, meat quality grades are influenced by carcass weight, and size was determined by loin-eye area or backfat thickness. In the present study, no differences of quality grade among the dietary groups may be due to the visual appraisal of meat quality grade such as marbling is not well matched sometimes when the differences of intramuscular fat content or carcass characteristics were small. Fiems et al. (2000) demonstrated the possibility of increasing intramuscular fat content without increasing the total fat content in the carcass. For this reason, more researches are needed to determine how dietary SCR influence meat quality grade in beef cattle.

Chemical composition of meat

Table 5 shows the chemical composition of beef depending on the dietary level of SCR. Crude protein contents were slightly declined with the dietary level of SCR. On the contrary, crude fat contents increased with the dietary level of SCR. In crude fat contents, T1 group was 37.56±10.26% while T2 and T3 groups were 41.78±8.98 and 45.92±7.27%, respectively. In total carbohydrate contents, T1, T2 and T3 groups were 8.71±2.60, 8.46±1.65 and 11.28±3.39%, respectively, without statistical significance. In crude ash contents, T1, T2 and T3 groups were 1.07±0.01, 1.05±1.15 and 1.17±0.01%, respectively. In general, meat qualities are largely influenced by marbling or meat color, especially, marbling or intramuscular fat content play an important role in flavor, texture, tenderness and water-holding capacity. Marbling improves meat tenderness by reducing bulk density and decreasing the strength of the connective tissue, moreover, subcutaneous fat may improve tenderness by reducing cold-shortening (Fiems et al., 2000). In the present study, crude fat content was increased by dietary SCR. It may be closely related with the increase of ADG and DMI. Marbling often has been implicated as a contributing factor to beef palatability and is used as the most important factor in evaluating the beef quality (Tatum et al., 1982). It appears that increase in fat content in loin by dietary SCR would have a positive impact on the production of high-quality meat.

Conclusion

Feeding of SCR changed ADG, DMI, carcass characteristics and chemical composition of meat in Hanwoo steer. Findings from this study suggest that SCR would be a good feed for castrated beef cattle to enhance productivity and improve quality of meat. It would be useful from the point of view of low cost animal feeding or reduction of the residue.

ACKNOWLEDGEMENTS

This work was carried out with the support of the "Cooperative Research Program for Agriculture Science and Technology Development (Project No. PJ907038)" Rural Development Administration, Republic of Korea. The research reported in this paper was also carried out as a part of the project promoted by Icheon Agricultural Technology Center, Konkuk University, and Rural Development Administration.

REFERENCES

Abe A (2001). Usage of food processing by-product and TMR center. Proceeding of Symposium of Research Society of TMR pp.1-84.

AOAC (1990). Official methods of analysis. 15th edn. Association of Office Analytical Chemists. Arlington, Virginia.

FCC (1981). Food chemical codex. National Academy of Science pp. 283-286.

Feng J, Liu X, Xu ZR, Lu YP, Liu YY (2007). The effect of Aspergillus oryzae fermented soybean meal on growth performance, digestibility of dietary components and activities of intestinal enzymes in weaned piglets. Anim. Feed Sci. Technol. 134:295-303.

Fiems LO, Campeneere SD, Smet SD, Van de Voorde G, Vanacker JM, Boucqué CV (2000). Relationship between fat depots in carcasses of beef bulls and effect on meat colour and tenderness. Meat Sci. 56:41-47.

Kim JI, Kang MJ (2009). Soybean health befefits of applications in food. Korea Soybean Digest 26:1-9.

Kim SW, Mateo RD, Ji F (2005). Fermented soybean meal as a protein source in nursery diets replacing dired skim milk. J. Anim. Sci. 83 Supp. 116.

Kwak WS, Yoon JS (2003). On-site output survey and feed value evaluation on agro-industrial by-products. J. Anim. Sci. Technol. 45:251-264.

Liener IE, Kakade ML (1980). Protease inhibitors, I. E. Liener, Edt. Toxic Constituents of Plant Foods. Academic Press pp. 7-71.

Moon SH, Jeon BT, Kim YC (1999). Effect of feeding soybean curd meal

and brewer's grain silage on the velvet production in spotted deer. Konkuk Nat. Sci. J. 10:131-138.
National Livestock Cooperatives Federation (NLCF) (2010). Korean carcass grading standard. National Livestock Cooperatives Federation.
Romney DLL, Gill M (2000). Intake of forages. In Forage Evaluation in Ruminant nutrition. D. I. Givens et al. (eds). CABI publishing pp. 170-178.
SAS Institute Inc. (2001). The SAS program for window. The SAS Institute, Inc., Cary, North Carolina.
Tatum JD, Smith GC, Carpenter ZL (1982). Interrelationships Between Marbling, Subcutaneous Fat Thickness and Cooked Beef Palatability. J. Anim. Sci. 54:777-784.
Vee V, Schaefer G (1950). The influence of the tempeh fungus on the soya bean. Documenta Neer. Indones. Morbis Trop. p. 20.