Influence of Whole Crop Corn Silage Ensiled with Poultry Manure on the Performance and Carcass Quality of Hanwoo Steers

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ABSTRACT : An experiment was conducted to study the performance and carcass characteristics of Hanwoo steers fed whole crop corn silage ensiled with poultry manure (PM) for 18 months. The experiment was designed as a randomized block design with three phases. Steers were allotted in one of three dietary treatments, which were ammonia-treated rice straw (AS), whole crop corn silage (CS) and whole crop corn+30% PM silage (based on DM; MS). All diets were supplemented with concentrate. Total body weight gain and average daily gain (ADG) in MS group were increased ($p<0.05$) by 6% over AS group. The MS treatment enhanced ($p<0.05$) total and daily intakes of forage compared with the AS and CS treatments while there was compensatory effect on concentrate intake by AS group. Carcass characteristics were improved by feeding MS. MS increased ($p<0.05$) carcass weight and marbling score (7.5 and 22.5% of AS, respectively), and reduced ($p<0.05$) backfat thickness (13.2 of AS and 16.6% CS). Carcass grade and meat quality grade were also improved by MS compared with AS and CS. Under the conditions of this study, MS was an efficacious replacement for corn silage for steers. *(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 8 : 1133-1137)*

Key Words : Corn Silage, Poultry Manure, Performance, Carcass Characteristics

INTRODUCTION

Poultry manure (PM), a waste product of the poultry industry, can be used as a good source of dietary crude protein for ruminants, because it is high in crude protein (above 30%) and mineral contents (e.g. calcium and phosphorus) (Bhattacharya and Fontenot, 1965). The high crude protein content of PM makes it a potentially valuable material to ensile with low protein corn forage. Although the major hazard areas associated with feeding of animal waste are pathogenic organisms, heavy metals and pesticides and drug residues (McCaskey et al., 1985), processing of PM before using as an animal feed, destroys pathogens and may enhance the preservation quality and palatability. Ensiling poultry manure with corn and sorghum forages (Chaudhry et al., 1993; Al-Rokayan et al., 1998) reduced pathogen numbers. Harmon et al. (1975a, b) reported improved fermentation quality and feeding value of whole crop corn forage when ensiled with PM and fed to sheep. Whole crop corn ensiled with PM also showed a higher palatability and digestibility in cattle, goats and sheep (Spoelstra et al., 1985; Kim et al., 1993; Kim et al., 2000).

The practical potential of ensiling PM with forages or high-moisture corn grains was demonstrated in several experiments carried out in Virginaia, USA (Caswell et al., 1977 and 1978). They reported that the palatability, live weight and carcass quality of cattle fattened on corn forage ensiled with PM was superior to those fed corn forage silage plus soybean meal.

Therefore, it has been shown that whole crop corn forage ensiled with PM can be a useful feed for ruminants.

The present experiment was conducted to examine the effect of 18 months of feeding of whole crop corn silage ensiled with layer manure on the performance and carcass characteristics of Hanwoo steers.

MATERIALS AND METHODS

Animal management

An experiment was conducted from October 5, 1997 to April 6, 1999 (18 months) on Yul-Rim Farm, Sanchung, Korea. Sixty native Korean beef steers (Hanwoo) were used. Calves of 4 to 5 months of age and similar live weights were purchased at a local livestock market on September 1997, and were castrated two weeks later.

Experimental design and treatments

Following two to three week adjustment period, the calves were assigned randomly to one of three dietary treatments and housed in total confinement in a concrete-floored barn. Each treatment diet was fed to two pens as replicates with 10 steers in each pen (11×8 m). The dietary treatments investigated were ammonia-treated rice straw (AS), whole crop corn silage (CS) and whole crop corn+30% poultry manure (based on DM; MS). AS was considered a control diet because of wide use of the forage source for Hanwoo steer feeding in Korea. All diets were supplemented with concentrate. The experimental period

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Table 1. The chemical composition (g/kg DM unless stated otherwise) of the experimental diets

	Treatments[1]		
	AS	CS	MS
Dry matter (g/kg)[2]	852.1	334.4	391.2
Crude protein	83.9	93.1	149.5
Ether extract	13.9	28.4	35.1
Crude fiber	313.5	187.5	171.2
Crude ash	139.7	59.4	142.2
Neutral detergent fiber	636.5	462.1	377.9
Acid detergent fiber	417.8	311.7	257.5
Nitrogen-free extract	449.0	637.5	500.2

[1] AS: Ammonia-treated rice straw; CS: Whole crop corn silage; MS: Whole crop corn silage ensiled with 30% poultry manure.
[2] Dry matter of CS and MS silages was measured by toluene distillation.

was divided to three stages, which were growing period (5 to 12 months of age), early fattening period (13 to 18 months of age) and late fattening period (19 to 23 months of age). Concentrate in all diets was given 1.67, 1.64 and 1.70% of body weight of the animals in the growing, early fattening and late fattening periods. Rice straw in the AS diet was given at level of 1.27, 0.66 and 0.86% of body weight in the growing, early fattening and late fattening periods respectively. Silages in the CS and MS diets were given at level of 1.31, 0.86 and 0.30% of body weight in the growing, early fattening and late fattening periods, respectively. Although there is no certain feeding standard for Hanwoo steers in Korea, the different feeding periods and the portions of dietary constituents fed during these periods in the present study were based on a Hanwoo feeding program for high quality meat production from RDA (Rural Development Administration) and NACF (National Agricultural Cooperatives Federation). Again, diets were balanced to meet or exceed NRC (1996) requirements.

The chemical composition of the experimental diets is shown in table 1. Whole crop corn forage was grown at Yul-Rim Farm and harvested at the dough stage of grain development in early August 1997, and was cut into 2 to 3 cm lengths with a forage cutter. The poultry manure was collected from a local poultry farm and was sun-dried to >80% dry matter content after feathers and foreign substances were removed. Before adding to corn forage, the PM was ground to <1 mm through a Wiley mill. The pure corn forage and the corn forage mixed with 30% PM (based on DM of corn forage) prior to ensiling using a small mixer were ensiled in separate trench silos. The silages were fed to the animals two months after ensiling. For the preparation of ammonia-treated rice straw, rice straw was chopped (2 to 3 cm lengths) and sprayed with a 25% ammonia solution at the rate of 3 g nitrogen/kg DM prior to 30 day incubation at room temperature.

Table 2. The chemical composition (g/kg DM unless stated otherwise) of the concentrate supplements

Item	Age of steers (months)			
	5 to 6	7 to 12	13 to 18	19 to 23
Dry matter (g/kg)	873.6	877.5	873.7	874.5
Crude protein	171.0	153.9	136.8	125.0
Ether extract	19.4	28.5	19.4	22.5
Crude fiber	114.2	102.5	123.2	150.0
Crude ash	125.4	125.0	126.7	110.0

The concentrate supplements were supplied by a commercial feed manufacture (Jeil Jedang Ltd, Inchon, Korea) and were fed at different level depending on the age of the animals (table 2). Since the feed manufacture produces four different concentrates depending on the age of steers, the concentrate feeding was divided to four periods. Water and mineral blocks containing 98% NaCl, 4% Zn, 0.4% Fe, 0.3% Mn, 0.2% Cu, 0.02% Se, 0.007% I, and 0.007% Co were freely accessible during feeding .

Steers were weighed every 28 d throughout the growing and fattening phases. Feed intake was measured once a week from each pen and daily feed intake was calculated. Feed samples were collected weekly, and were bulked on a monthly basis before chemical analysis.

Chemical analysis

Feed samples were taken form a daily ration, dried in a forced-air oven at 60°C, ground to pass a l-mm screen, and analyzed for DM, nitrogen (N), ether extract, crude fiber and crude ash (AOAC, 1990). Silage dry matter was determined by toluene distillation (Dewar and McDonald, 1961). NDF and ADF analyses were done by the methods of Van Soest and Wine (1967), and Van Soest (1963), respectively.

Carcass evaluation

Steers after 18 months were slaughtered after fasting for 24h. Carcasses were chilled at 0 to 2°C for 24 h and graded for quality and yield factors by trained carcass evaluators, guided by the Korean meat-grading scheme. Carcass weight, carcass yield, back-fat thickness and size of loin-eye area were assessed. Carcass grade was classified with a scale of A, B or C where A > 69.0 % of carcass grade score, 69.0 < B > 66.0 and C < 66.0. The carcass grade score was measured by a carcass grade index:

Carcass grade index=65.834–[0.393×back-fat thickness (mm)] + [0.088×longissmus muscle area (cm_2)] - [0.008 ×carcass weight (kg)]

Marbling score was evaluated and scored on a scale of l to 7, where l=very abundant and 7=traces. Quality grade was scored on a scale of l to 3, which was mainly determined by marbling score but also by meat color, fat color and maturity. Meat fat color was scored on a scale of

Table 3. The growth, feed intake and feed conversion rate of Hanwoo steers over 18 month trial when fed ammonia-treated rice straw, whole crop corn silages ensiled with or without poultry manure

Items	Treatments[1]		
	AS	CS	MS[2]
Growing performance			
Initial body weight (kg)	126.5	136.0	143.8
Final body weight (kg)	560.7	585.3	603.6
Body weight gain (kg)	434.2[b]	449.3[ab]	459.8[a]
Average daily gain (g/d)	794[b]	821[ab]	841[a]
Forage			
Total intake (kg DM)	1080.6[c]	1295.5[b]	1373.7[a]
Daily feed intake (kg DM/d)	1.98[c]	2.37[b]	2.51[a]
Concentrate			
Total intake (kg DM)	2914.8[a]	2736.5[b]	2742.6[b]
Daily feed intake (kg DM/d)	5.33[a]	5.00[b]	5.01[b]
Total feed intake (kg DM)	3995.4	4032.0	4116.3
Feed conversion rate[2]	9.20	8.98	8.95

[1] AS: Ammonia treated rice straw + concentrate; CS: Whole crop corn silage; MS: Whole crop corn silage ensiled with 30% poultry manure (DM basis).

[2] Feed conversion rate: Total feed intake/body weight gain.

[a,b,c] Means in the same row with different superscripts differ significantly ($p<0.05$).

1 to 7, where 1=white and 7=very yellow. Meat color was scored on a scale of 1 to 7, where 1=dark pink and 8=very dark red.

Statistical analysis

The data were analyzed as a randomized complete block design using GLM (general linear model) procedures of SAS (1990) and statistical significance among treatment means was determined by Duncan's multiple range test.

RESULTS AND DISCUSSION

The performance data for the three dietary treatments for the whole trial period are shown in table 3. Although there was no difference in final body weight throughout the entire period between the treatment groups, bodyweight gain and ADG of Hanwoo steers fed MS were greater ($p<0.05$) than the AS group. Total and daily intakes of forage were highest ($p<0.05$) in steers given corn silage ensiled with poultry manure compared with AS and CS. In contrast to the intake of forage, the total and daily intakes of concentrate were highest ($p<0.05$) in steers given rice straw diet. Both silages tended to enhance feed conversion rate compared with AS.

The effect of the experimental diets on carcass characteristics is shown in table 4. Carcass weight of steers fed MS was significantly higher ($p<0.05$) than AS while carcass yield did not differ between the dietary treatments.

Table 4. Carcass characteristics of Hanwoo steers over 18 month trial when fed ammonia-treated rice straw, whole crop corn silages ensiled with or without poultry manure

Items	Treatments[1]		
	AS	CS	MS[2]
Live body weight (kg)	560.7	585.3	603.6
Carcass weight (kg)	325.2[b]	341.3[ab]	351.7[a]
Carcass yield (%)	58.1	58.5	58.5
Back-fat thickness (mm)	12.1[a]	12.6[a]	10.5[b]
Loin-eye area (cm^2)	77.5	77.3	79.4
Carcass grade (A:B:C)	2: 18: 0	1: 17: 2	5: 15: 0
Marbling score	2.79[b]	3.55[a]	3.60[a]
Meat color	4.64	4.50	4.50
Meat fat color	2.36	2.35	2.30
Quality grade (1:2:3)	4: 13: 3	9: 9: 2	9: 9: 2

[1] AS: Ammonia treated rice straw + concentrate; CS: Whole crop corn silage; MS: Whole crop corn silage ensiled with 30% poultry manure (DM basis).

[a,b] Means in the same row with different superscripts differ significantly ($p<0.05$).

Steers receiving MS had less backfat ($p<0.05$) than AS and CS. Both silage diets increased ($p<0.05$) marbling score of steers over AS. Carcass grade A was given to 25% of steers fed MS compared with only 10% and 5% out of those fed AS and CS, respectively. Again, 45% of steers fed both silages graded as No. 1 for meat quality compared with only 20% for AS. There was no treatment effect in meat and fat color.

Results of voluntary feed intake trials and the palatability studies had showed that poultry manure addition to corn silage significantly improved dry matter intake (Kim et al., 2000; Kim et al., 1993). In the present experiment, the forage intake of steers fed corn silage ensiled with poultry manure was increased over the whole experimental period. This may be due to the higher bulk density of manured silages which were more compact (greater mass/volume) than the untreated silage (Harmon et al., 1975b). The higher forage intake was also induced by higher digestibility of nutrients in silage ensiled with PM, especially that of non-structural carbohydrate which was significantly increased (Kim et al., 2000). In contrast to forage intake, concentrate intake seemed to compensate for the forage intake in the AS and CS groups. An advantage in feeding corn silage ensiled with poultry manure compared with untreated corn silage or straw could come from reduced requirement for expensive concentrates.

Steers fed MS gained at a faster rate than AS over the whole period. It is possible to explain the better performance observed for steers receiving MS that availability of dietary protein was higher than AS, although this does not explain the lack of difference in total body weight gain and ADG of steers fed MS compared with those fed CS when total protein intakes over the growing

period were 693, 677 and 853 g/d for AS, CS and MS, respectively. It is suggested that the reason for similar performance between MS and CS groups is due to the similar feed conversion rate while the feed conversion rate of AS was lowest among the three dietary treatments.

There is evidence that increasing dry matter intake increases digesta flow and microbial yield (ARC, 1984; Owens and Goetsch, 1986), which are related to improvement of performance and meat quality. Bacterial crude protein (BCP) can supply from 50% (NRC, 1985; Spicer et al., 1986) to essentially all the metabolizable protein (MP) required by beef cattle, depending on the RUP content of the diet. Clearly, efficiency of synthesis of BCP is critical to meet the protein requirements of beef cattle economically. Kim et al. (2000) confirmed that feeding MS silage to sheep increased microbial protein reaching the small intestine. Therefore, the higher availability of metabolizable protein in the MS group probably improved the growing performance and meat quality of the steers used here.

In the present study, feeding MS improved carcass characteristics of Hanwoo steers compared with those fed AS and MS. This agrees with results of Caswell et al. (1977 and 1978), who observed improvement of live weight gain and carcass quality of finished cattle fed corn-forage poultry-manure silage over those fed corn forage silage plus soybean meal.

Under the conditions of this study, adding poultry manure to corn silage improved the feeding value of the corn silage as a feed source for steers. More research is required to determine the most appropriate supplementary level of poultry manure to corn silage for beef cattle production.

Due to the complete import liberalization of beef including live animals since year 2001, Korean beef producers have mainly been focusing on high quality meat production and reduction of production cost, which could be a way to compete against the lower priced imported beef in domestic markets. Therefore, the work like the present one to improve the feeding value using animal wastes such as poultry manure could be important for beef production in Korea, not only to improve meat quality but also to lower feed cost.

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