Influence of Dietary Addition of Dried Wormwood (*Artemisia* sp.) on the Performance and Carcass Characteristics of Hanwoo Steers and the Nutrient Digestibility of Sheep

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ABSTRACT : Two experiments were conducted to study the performance and carcass characteristics of Hanwoo (Korean native beef cattle) steers (Experiment 1) and the nutrient digestibility of sheep (Experiment 2) when the animals fed diets containing four levels of dried wormwood (*Artemisia* sp.). For both experiments the animals were given a basal diet consisting of rice straw and concentrate mixed at 3:7 ratio (on DM basis). In Experiment 1, the treatments were designed as a completely randomized design with two feeding periods. Steers were allotted in one of four dietary treatments, which were designed to progressively substitute dried wormwood for 0, 3, 5 and 10% of the rice straw in the basal diet. Bodyweight gain and average daily gain (ADG) of Hanwoo steers fed diets containing the 5 and 10% wormwood inclusion were greater ($p<0.05$) than the 3% wormwood-feeding group. Total and daily intakes of roughage and concentrate were not altered by all levels of dried wormwood inclusion. However, the 10% dried wormwood inclusion led to increased total feed intake ($p<0.05$) compared with that of the 0 and 3% of dried wormwood inclusion. Carcass weight, carcass yield and backfat thickness were not altered by dried wormwood inclusion. The highest level of dried wormwood inclusion resulted in significantly increased ($p<0.05$) loin-eye area compared with the 0 and 5% levels of dried wormwood inclusion. Experiment 2 was designed by a 4× 4 Latin square with four periods. Sheep were allocated in one of four dietary treatments as same as in Experiment 1. Digestibilities of DM and TDN were significantly increased ($p<0.05$) in sheep fed the diet containing all three levels of dried wormwood inclusion compared with the control treatment. Digestibilities of CP and crude fiber in the 5% dried wormwood inclusion highly increased ($p<0.05$) up to 8.2 and 5.5% respectively relative to the control treatment. The palatability was significantly improved ($p<0.05$) by the 5% dried wormwood inclusion compared with the control treatment. It is concluded that feeding diets containing dried wormwood substituted for equal weights of rice straw at 5 and 10% levels would be anticipated to provide better quality roughage for beef cattle production and higher income for beef cattle producers. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 3 : 390-395)***

Key Words : Dried Wormwood, Hanwoo Steers, Performance, Carcass Characteristics, Nutrient Digestibility

INTRODUCTION

Wormwood (*Artemisia* sp.) belongs to the useful aromatic and medical plants comprising about 300 species which are found in the northern hemisphere (Weyerstahl et al., 1987). In Korea, 30 taxa were reported (Lee, 1979). It is used to aid digestion, exterminate parasites, and cure gastroenteric disorders, constipation and neuralgia in Chinese medical practices (Kim, 1984). Herbs such as wormwood used as feed additives contain active ingredients such as essential micronutrients, unknown factors, hormone-like agents, antimicrobial agents, probiotics, antioxidants and immune-promoting agents. Also, the oriental wormwood composes of alkaloid, vitamins (vitamin A, B_1, B_2 and C) and minerals (Ca, P and Fe) (Lee, 1965).

Besides, due to the complete market opening of live animals including beef cattle in 2001, beef producers in Korea have changed the conventional feeding system to high production strategies for highly competitive and good quality Hanwoo (Korean native beef cattle) meat production. Several feed additives with functional and bioactive properties such as Oriental medical by-products and pine needle etc. have been used to produce good quality meat and to provide health benefit for consumers. However, the strategy using bioacitive and functional feed additives in beef production has not been successive as there is no feeding standards and studies for high quality beef production.

Wormwood is known as a functional and medical herbal plant as mentioned above. Therefore, the dietary supplementation of wormwood might result in good quality meat production. However, none of research has been conducted to examine the effect of wormwood supplementation in the practical diets of beef cattle on performance or meat quality. In the present paper, two experiments were conducted to determine the suitable dietary supplementation level of dried wormwood by examining the effect of dietary inclusion of dried wormwood on the performance and carcass characteristics of Hanwoo steers, and the nutrient digestibility of sheep when fed dried wormwood in three different levels.

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MATERIALS AND METHODS

Experimental animals and their management

Experiment 1 was conducted for 6 months in a beef cattle farm located in Geochang-gun, Korea. Twenty Hanwoo steers were used. Steers (450±10 kg) were purchased at a local livestock market. In Experiment 2, four healthy mature Corriedale male sheep were used. Average body weight of the animals was approximately 50.7±3.2 kg at the start of the experiment. The steers and sheep were given a diet at 3 and 2% of body weight in dry matter (DM) basis, respectively. Food was given in two equal meals at 08:00 and 16:00. Water and mineral blocks were freely accessed.

For both experiments the animals were given a basal diet consisting of rice straw and concentrate mixed at 3:7 ratio (on DM basis). Wormwood was collected between May and June, 2000 in the fields around the farm and then sun-dried for 2 days. The chemical compositions of rice straw and dried wormwood are shown in table 1. The concentrations of crude protein for rice straw and dried wormwood are 5.45 and 15.89%, respectively.

The concentrate supplements were supplied by a feed manufacture and were fed at different compositions depending on the age of the animals in the experiments (table 2).

Experimental design and treatments

Experiment 1 : The experiment was designed as a completely randomized design. Following 5 day adjustment period, the steers were assigned randomly to one of four dietary treatments and housed individually in stanchion stalls. The four dietary treatments were designed to progressively substitute 0, 3, 5 and 10% of the rice straw with equal weights of dried wormwood in the basal diet as described above. Each treatment diet was fed individually to five steers. The experimental period was divided into two stages, which are early fattening period and late fattening period. Steers were weighed every month throughout the fattening periods. Feed intake was measured once a week from each stall and daily feed intake was calculated. Feed samples were collected weekly, and were bulked on a monthly basis before chemical analysis.

Table 1. The chemical composition (%, DM basis) of rice straw and dried wormwood (*Artemisia* sp.) used in the experiments

Item	Rice straw	Dried wormwood
Dry matter	87.32	81.28
Crude protein	5.45	15.89
Ether extract	1.58	4.31
Crude fiber	34.81	22.70
Crude ash	14.56	8.52
Nitrogen-free extract	43.60	48.58

Table 2. Formula and chemical composition (% DM basis) of the concentrate supplements in the experiments

Ingredients	Early fattening	Late fattening
Corn grain	26.53	36.57
Wheat grain, 11.5%	12.93	15.00
Wheat flour	4.00	6.00
Lupin, 31%	5.00	-
Wheat bran	11.98	5.12
Corn gluten feed	3.00	3.00
Mixed fiber	-	8.00
Tapioca pellet	8.00	-
Cane molasses	5.00	5.00
Rapeseed meal	-	3.72
Coconut meal, 20.5%	12.00	10.00
Palm meal	6.50	5.50
Mixed fiber	-	5.05
Soybean meal	-	1.15
Kapok seed meal, 33.5%	1.00	1.00
Salt	0.60	0.60
TCP, 18%	0.09	-
Limestone, 1 mm	1.53	1.39
Calcium sulfate	0.10	-
Vitamin premix[1]	0.10	0.10
Mineral premix[2]	0.10	0.10
Myco-curb	0.03	-
Sodium bicarbonate	-	0.70
Kelp meal	0.10	-
Total	100	100
Chemical composition[3]		
Crude protein	12.00	12.15
Ether extract	3.24	3.24
Neutral-detergent fiber	22.45	20.89
Acid-detergent fiber	9.80	9.91
Crude ash	5.70	5.70
Ca	0.80	0.80
P	0.40	0.40
TDN	73.43	70.11

[1] Vitamin premix contains: Vit. A, 4,000,000 IU; Vit. D_3, 450,000 IU; Vit. E, 22,000 IU; Vit. K_3, 880 mg; Vit. B_1, 500 mg; Vit. B_2, 10 mg; pantothenic acid, 5,000 mg; Niacin, 12,000 mg; biotin, 210 mg; and folic acid, 200 mg.

[2] Mineral premix contains: $FeSO_4$, 52,500 mg; $CoSO_4$, 170 mg; $CuSO_4$, 7,300 mg; $MnSO_4$, 26,000 mg; $ZnSO_4$, 31,000 mg; I, 630 mg and Se(Na), 165 mg.

[3] Calculated value.

Experiment 2 : The experimental design was a 4×4 Latin square with 4 periods. Sheep were individually reared in metabolism cages. Sheep were allocated in one of four dietary treatments as same as in Experiment 1. Each metabolism trial consisted of a 10 day preliminary period and following a 5 day collection period for total feces. Feces were collected just before the morning ration. After all the metabolism trials, palatability was estimated. Voluntary food intake (palatability) was measured in 15 minutes each at 09:00, 12:00 and 15:00 for 3 days; 3

determinations were made by a 4×4 Latin square design. After measurement at 15:00, total amounts of intake were calculated for the day and the deficient dry matter was individually given to the animals.

Chemical analysis

Feed and fecal samples were taken, 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).

Carcass evaluation

All steers at the end of Experiment 1 were slaughtered after fasting for 24 h. 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 scored by combination of carcass yield and quality grade. Carcass yield was classified with a scale of A+, A, B+, B, C+ or C. Quality grade was scored on a scale of 1 to 3, which was mainly determined by marbling score but also by meat color, fat color and maturity. Marbling score was evaluated and scored on a scale of 1 to 7, where 1=very abundant and 7=traces. Meat fat color was scored on a scale of 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 completely randomized design for Experiment 1 and a 4×4 Latin square design for Experiment 2 using GLM (general linear model) procedures of SAS (1990) and statistical significance among treatment means was determined by Duncan's multiple range test.

RESULTS

The performance and feed intake data for the four 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 average daily gain (ADG) of Hanwoo steers fed 5 and 10% of dried wormwood instead of rice straw in roughage source were greater ($p<0.05$) than those of the 3% dried wormwood-feeding group. Total and daily intakes of roughage and concentrate were not altered by all dried wormwood treatments. However, the 10% dried wormwood-feeding group showed higher ($p<0.05$) total feed intake (7.4 to 8.8% increases) than those of the 0 and 3% of dred wormwood-feeding groups. Although significant influence of dried wormwood inclusion on total feed intake, body weight gain and ADG in Hanwoo steers, the feed conversion rate did not significantly differ between treatments.

The effect of the experimental diets on carcass characteristics is shown in table 4. Carcass weight, carcass yield and backfat thickness of all feeding groups were not altered. The 10% dried wormwood inclusion significantly increased ($p<0.05$) the size of loin-eye area by 5 to 7 cm^2 over the 0 and 5% dried wormwood inclusion. There was no treatment effect on meat and fat color. All animals in the 5 and 10% dried wormwood-feeding groups scored No. 1 (the highest grade) for meat quality grade but in the 0 and

Table 3. Effects of dietary inclusion of dried wormwood (*Artemisia* sp.) on the growth, feed intake and feed conversion rate of Hanwoo (Korean native beef cattle) steers fed the diet containing rice straw and concentrate in Experiment 1

Items	Percentage of dried wormwood in roughage				SEM
	0	3	5	10	
Growing performance					
Initial body weight (kg)	468.8	470.0	470.4	460.8	3.40
Final body weight (kg)	608.7	603.5	621.6	618.7	8.70
Body weight gain (kg)	139.9^{ab}	133.5^{b}	151.2^{a}	157.9^{a}	3.98
Average daily gain (g/d)	0.78^{ab}	0.74^{b}	0.84^{a}	0.88^{a}	0.03
Roughage					
Total intake (kg DM)	233.2	241.1	246.3	257.2	7.60
Daily intake (kg DM/d)	1.30	1.34	1.37	1.43	0.05
Concentrate					
Total intake (kg DM)	1578.5	1546.2	1636.3	1687.7	48.40
Daily intake (kg DM/d)	8.77	8.60	9.09	9.38	0.59
Total feed intake (kg DM)	1811.7^{b}	1787.3^{b}	1882.6^{ab}	1944.9^{a}	36.10
Feed conversion rate[1]	12.95	13.39	12.45	12.32	0.35

[1] Feed conversion rate: total feed intake/body weight gain.

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

SEM=standard error of the mean.

Table 4. Effects of dietary inclusion of dried wormwood (*Artemisia* sp.) on carcass characteristics of Hanwoo (Korean native beef cattle) steers fed the diet containing rice straw and concentrate in Experiment 1

Items	Percentage of dried wormwood in roughage				SEM
	0	3	5	10	
Carcass weight (kg)	352.7	367.5	375.8	390.4	15.30
Carcass yield (%)	66.60	67.54	65.65	67.97	0.79
Backfat thickness (mm)	14.0	13.0	16.3	12.7	1.24
Loin-eye area (cm^2)	80.00^{b}	85.67^{ab}	82.33^{b}	87.00^{a}	1.65
Meat color	4.7	4.3	4.7	4.7	0.02
Fat color	2.7	3.0	3.0	2.7	0.02

[a,b] Means in the same row with different superscripts differ significantly ($p<0.05$).
SEM=standard error of the mean.

3% dried wormwood treatments, one out of five steers was classified to No. 2 grade for meat quality (data not shown).

Digestibilities of DM and ether extract (EE) were significantly increased ($p<0.05$) in sheep fed the diet containing 5% dried wormwood compared with those of the other treatments, whilst DM digestibility was higher ($p<0.05$) in sheep fed the diets containing 3 and 10% dried wormwood than that of the control treatment (table 5). Digestibilities of CP and crude fiber in the 5% wormwood inclusion treatment highly increased ($p<0.05$) up to 8.2 and 5.5% respectively relative to the control treatment. The digestibility of crude ash was highest in sheep fed the 5% dried wormwood diet, whilst in sheep fed the 0 and 10% dried wormwood diets the digestibility of crude ash was lowest ($p<0.05$). TDN digestibility was increased ($p<0.05$) by all levels of dried wormwood inclusion compared with the control treatment. Since sheep fed 5% dried wormwood consumed more feed than those fed 0% wormwood in a certain period, the palatability was significantly better ($p<0.05$) in the 5% dried wormwood treatment than in the control treatment, whilst the 3 and 10% dried wormwood treatment did not significantly improve palatability relative to the control treatment.

DISCUSSION

Dried wormwood contains higher crude protein, crude fat and organic matter than rice straw (table 1). Thus, when dried wormwood was substituted for 3, 5 and 10% of the rice straw in the basal diet, steers consumed more nutrients. The intakes of CP in roughage and total feed were approximately 70.9, 1.12; 77.1, 1.13; 81.8, 1.17 and 92.9 g/d, 1.23 kg/d for the 0, 3, 5 and 10% dried wormwood treatments, respectively. Steers fed diets containing 0, 3, 5 and 10% of the rice straw with dried wormwood consumed 1.11, 1.15, 1.18 and 1.23 kg/d and 9.38, 9.26, 9.75 and 10.08 kg/d of OM in roughage and total feed, respectively. From above rough calculation, the progressively increased intake of wormwood led to corresponding increase in the CP and OM intakes. However, despite its linear increase of CP and OM intakes, there was no effect on body weight gain and ADG, which remained unaffected when the intake of wormwood progressively increased.

Although the 3% wormwood inclusion despite the higher nutrient digestibility with sheep did not influenced the total feed intake compared with the control treatment, it is likely that the higher total feed intake in steers fed diets containing 5 and 10% dried wormwood than that of the

Table 5. Effects of dietary inclusion of dried wormwood (*Artemisia* sp.) on the nutrient digestibility (%) and palatability (g/d) in sheep fed the diet containing rice straw and concentrate in Experiment 2

Items	Percentage of dried wormwood in roughage				SEM
	0	3	5	10	
Apparent digestibility					
Dry matter	42.38^{c}	47.13^{b}	49.90^{a}	45.08^{b}	0.72
Crude protein	53.23^{b}	53.91^{ab}	57.60^{a}	55.43^{ab}	1.33
Ether extract	71.82^{b}	75.36^{b}	81.15^{a}	73.05^{b}	1.89
Crude fiber	68.52^{b}	70.46^{ab}	72.32^{a}	70.09^{ab}	0.78
Crude ash	59.53^{c}	65.89^{b}	68.97^{a}	61.95^{c}	0.99
TDN	50.73^{c}	56.67^{b}	67.26^{a}	60.31^{b}	1.35
Palatability	80.38^{b}	109.74^{ab}	131.67^{a}	101.80^{ab}	10.06

[a,b,c] Means in the same row with different superscripts differ significantly ($p<0.05$).
SEM=standard error of the mean.

control group in Experiment 1 could be induced by the higher digestibility of nutrients in sheep given the dried wormwood-containing diets in Experiment 2. Again, there is evidence that increasing dry matter intake increases digesta flow and microbial yield (ARC, 1984; Owens and Goetsch, 1984), which are related to improvement of performance and meat quality. In the present study, when 3% dried wormwood was included in roughage of the basal diet, the ADG and feed conversion rate were lower by 5.1% and higher by 3.4%, respectively, than those when steers were given rice straw for solely roughage source. However, as the higher levels (5 and 10%) of dried wormwood inclusion tended to increase ADG up to 7.7 and 12.8%, respectively, and improve the feed conversion rate up to 3.9 and 4.9%, respectively, it is suggested that feeding the 5 and 10% of dried wormwood instead of rice straw is beneficial for Korean beef producers.

In the preliminary analysis with the extracts of wormwood in our lab, it was found that fresh wormwood contains 988 mg/100 g of phenolic acids as well as high electron donating ability, which suggests the high ability of antioxidation. Lee et al. (1992) identified catechol, vanillin, umbellinferone, *p*-coumaric acid, ferulic acid, caffeic acid, protocatechuic acid, *p*-hydroxy benzoic acid and syrigic acid. These phenolic acids are known to be high in antioxidant activity. Flavonoids, one of phenolic compounds, in wormwood and their considerable antioxidant activity were also reported (Hoffmann and Herrmann, 1982; Lee, et al., 1999). The activities of antioxidant enzymes including glutathione sulfur transferase (GST) and Cu, Zn-superoxide dismutase were increased by feeding the extracts of wormwood in rats (Nam et al., 1999). The rats ingested 5 to 10% wormwood (mugwort) water or ethanol extract-supplemented diets showed a significant increase in intestinal bifidobacteria and a decrease in clostridia and *E. coli* (Lee et al., 1995). The mechanism of antimicrobial effects of wormwood has not been clearly identified but essential oils from wormwood were reported to inhibit the growth of pathogens (Nagy, 1966; Farag et al., 1989). Especially, microbial (White, 1990,1991) and fungal (Espinosa-Garcia and Langenheim, 1991) growths were severely inhibited by terpenes in the essential oils of *Artemisia* species. The growth-promoting factor of effective microorganisms such as bifidobacteria and lactobacilli was reported due to supplying galactose and glucose as main water-soluble sugars in wormwood because bifidobacteria prefer to use mono- or oligosaccharides (Lee and Shin, 1996). Results of the better carcass grade and larger loin-eye area in steers fed the diet containing 10% dried wormwood should be caused by some functional ingredients such as flavonoids and other antioxidants in wormwood and an increase of effective microorganisms in the gut of steers, then altering fatty acid composition.

Herbal preparations often provide their effective action due to a multitude of agents present and not due to one specific concentrated and purified chemical. Though herbal preparations have been used in equine diets for centuries and their effectiveness proven on the basis of repeatability over time, the active agents in many of the herbs are still ill-defined. Therefore, feeding dried wormwood may have very powerful actions in animals including ruminants as reducing feed intake, and should be used with care because elevated doses of some herbs can stimulate undesirable side effects (Vandergrift, 1998). Again, wormwood have strong flavors, which may alter feed sensory characteristics and therefore affect feed intake. However, in the present study there was no adverse effects of all three levels of wormwood inclusion throughout the experimental period and even the palatability in sheep given the diet including 5% dried wormwood was significantly higher than that of the control treatment, in addition to a tendency in increased palatability in the 3 and 5% dried wormwood-feeding groups (table 5). Therefore, it is suggested that up to the 10% substitution of dried wormwood for the roughage source should be a safe amount for feeding Hanwoo steers.

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 possibly compete against the lower priced imported beef in domestic markets. Therefore, the work like the present one to improve the feeding value using bioactive and high nutritional herb plants such as wormwood could be important of beef production in Korea, not only improving meat quality but also to lowering feed cost.

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