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Effects of Black Sugar® and Mineral® Supplementation on Growth performance and Meat Quality of Hamwoo Steers in Fattening Period

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ABSTRACT

This study was carried out investigate the effects of dietary addition of mineral and sugar on the dry matter intake, daily gain, yield grade and quality grade of Hanwoo (*Bos taurus coreanae*) steers. Three diets fed to steers included a control diet (concentrate mix and rice straw : C) and two treatments diet (control diet + black sugar 100 g + mineral 100 g : T1, and control diet + black sugar 150 g + mineral 50 g : T2). The results are summarized as follows; total feeding intake, body weight gain and daily gain did not show significant differences among the three treatments. Cold carcass weight was significantly ($p<0.05$) higher in T2 than in the other two treatments (C and T1). There was no significant difference in yield traits of back fat thickness, *longissimus* muscle area and yield grade among the three treatments (C, T1 and T2). Marbling score showed significantly ($p<0.05$) higher in order of T2 (5.67) > T1 (4.67) > C (3.67). Meat color, fat color, texture and maturity were no significant difference. Quality grade was higher in T2 than in the other two treatments (C and T1), but there was no significant difference. The results show that marbling score and quality grade of Hanwoo can be increased by high dry matter intake with feeding addition of mineral and sugar.
(**Key words :** Black sugar, Mineral, Intake, Meat quality)

Ⅰ. INTRODUCTION

Sugars provide the major of carbohydrate for the growth of rumen microbes in diets of high daily gain in beef cattle (Hoover et al. 2006). Especially, sugar supplements are widely used as an energy source for beef cattle and can be combined successfully with multiple ingredients to alter its nutritional profile and palatability characteristics (Pate, 1983; Emanuele, 2004). Sucrose of sugar components initiated *in vitro* microbial growth most rapidly followed by pectin, starch and isolated neutral detergent fiber (Hall and Herejk, 2001). Sugars are available in different forms and amounts in forages (Berthiaume et al., 2010; Tas et al., 2006). Sugar cane is rich in sugar contents and consequently high in energy, but these benefits are limited by the high content of NDF and the low proportion of crude protein (Grant et al., 1995; Corrêa et al., 2003; Lascano et al., 2012). A food industry byproduct, such as citrus pulp, has a high proportion of carbohydrates and NDF. Molasses is a cost-effective sugar source and is useful because of the energy it supplies and the physical benefits it gives to the diet by reducing diet selection in animals (DeVries and Gill, 2012; Firkins and Eastridge, 2010). The content of the sugar contained in the feed plays an important role in VFA composition (Bowman and Huber, 1967; Campbell et al., 1970; Marty and Preston, 1970; Seibert, 1978). Total rumen VFA concentration or pH did not appear to be affected by the feeding of low level of molasses in most studies (Martin and Wing, 1966; Owen et al., 1967; Kellogg and Owen, 1969). However, the addition of up to 15% molasses to a high concentrate finishing diet did increase total VFA content of rumen fluid (Hatch and Beeson, 1972). In the daily gain, Baker (1966) reported that the addition of citrus molasses to a ground shell corn diet reduced rate of daily gain, but Lishman (1967) reported that the addition of cane molasses to a corn meal diet increased rate of daily gain.

The mineral is the important material for protein synthesis, carbohydrate metabolism, bone formation, nerve impulses and muscle activity in beef cattle (Bringe and Schulty, 1969; Pehrson et al., 1988; Wensing and Beynen; 1998).

In recent years, mineral has been studies to addition of diet for improve the meat quality and promotion of immunity

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(Cho et al., 2000; Yang et al., 2000; Kim et al, 2007). In particular, zeolite and bentonite has a mineral of the various components, and use of these is expected to be able to the improvement of meat quality and prevent diarrhea in beef cattle (Rindsig et al., 1969; Martin et al., 1969; Britton et al, 1978; Milne and Froseth, 1982; Ivancic and Weiss, 2001; Kim et al., 2007). Therefore, the objective of this study was to evaluate the effects of black sugar and mineral on dry matter intake, daily gain, meat yield traits and meat quality traits in final fattening Hanwoo.

Ⅱ. MATERIALS AND METHODS

1. Animals, experimental design and diets

This experiment was conducted during 140 days at Chungchon, Goesan gun, Chungcheongbuk-do, Korea. And, twelve korean native cattle (24 month of steer Hanwoo) were divided into three groups, including the control, T1 and T2 groups. Each Hanwoo's performance prior to the experiment are described in Table 1.

Table 1. Body weight of steer Hanwoo at the begging of experiment

Items	Treatments		
	C	T1	T2
IBW[1)]	595.6±19.4	580.3±17.0	612.7±29.0

IBW[1)]: Initial body weight. C: concentrate free + rice straw 1 kg, T1: concentrate free + rice straw 1 kg + black sugar® 100 g + mineral® 100 g, T2: concentrate free + rice straw 1 kg + black sugar® 150 g + mineral® 50 g.

Table 2. Experimental design

Items	Treatments		
	C	T1	T2
Feeding method			
Concentrate	*ad libitum*	*ad libitum*	*ad libitum*
Rice straw	1 kg	1 kg	1 kg
Black sugar®	0 g	100 g	150 g
Mineral®	0 g	100 g	50 g
Number of head per pen	4	4	4
Pen size	40.5 m^2	40.5 m^2	40.5 m^2

Steers were randomly allocated to three treatments by addition dietary. Treatments were as follows: C fed base diets, T1 fed black sugar 100 g and mineral 100 g with base diets, and T2 fed black sugar 150 g and mineral 50 g with base diets (Table 2). Pen sizes were 4.5 × 9 m (40.5 m^2). Diets were fed concentrate, rice straw and addition feed twice daily at 07:00 and 18:00 h. At all times, concentrated feed given *ad libitum*. Steers had *ad libitum* access to a trace mineralized salt mixture and water. For the black sugar® and mineral® were top dressed on concentrate. And, feed residues were weighed after collection.

2. Ingredient and chemical composition of the experimental diets

Chemical compositions of the experimental feed : The concentration was 13.1% crude protein, 28.8% neutral detergent fiber (NDF) and 83.25% total digestive nutrient (TDN) on a DM basis. It was a typical diet of final fattening steer. And, rice straw was 3.73% crude protein, 73.4% NDF and 40.15% TDN (Table 3).

The commercial black sugar® contained 398.60 kcal/100g energy, 98.65% carbohydrate, and 81,581.8 mg/100g sucrose. But, commercial mineral® had not detection. Mineral compositions of the mineral® and black sugar® are present in Table 5. The concentrate mix contained 30% corn grain, 16.5% wheat grain, 15% corn gluten, 10% wheat bran, 10% palm meal, and 18.5% others.

3. Experimental method and analysis

The feed samples were dried for 2 days at 55℃ to use

Table 3. The chemical compositions of concentrate and rice straw (DM %)

Items	CP[1)] (%)	EE[2)] (%)	CF[3)] (%)	CA[4)] (%)	NFE[5)] (%)	NDF[6)] (%)	TDN[7)] (%)
Concentrate	13.10	5.58	8.60	6.78	66.31	28.76	83.25
Rice straw	3.73	1.53	43.98	12.10	38.66	73.4	40.15

CP[1)]: crude protein, EE[2)]: ether extrace, CF[3)]: Crude fiber, CA[4)]: crude ash, NFE[5)]: nitrogen free extract, NDF[6)]: neutral detergent fiber, TDN[7)]: total digestive nutrient.

Table 4. The chemical compositions of black sugar® and mineral®

(as-fed basis)

Items	Energy (kcal/100g)	Carbohydrate (%)	Fructose (Kcal/100g)	Glucose (mg/100g)	Sucrose (mg/100g)
Black sugar®	398.60	98.65	180.38	544.28	81,581.8
Mineral®	0.00	0.00	0.00	0.00	0.00

Table 5. Mineral composition of black sugar® and mineral® (as-fed basis)

Items	Mineral® (as-fed basis)	Black sugar® (as-fed basis)
Calcium (mg/100g)	101.76±1.96	30.83± 0.17
Cobalt (mg/100g)	ND	0.02± 0.00
Copper (mg/100g)	2.92±0.03	0.32± 0.00
Iron (mg/100g)	330.83±5.53	1.40± 0.00
Potassium (mg/100g)	155.86±0.18	64.64± 0.30
Magnesium (mg/100g)	31.23±0.57	5.81± 0.22
Manganese (mg/100g)	17.18±0.29	0.04± 0.01
Molybdenum (mg/100g)	0.01±0.00	ND
Natrium (mg/100g)	27.30±0.17	3.72± 0.03
Phosphorus (mg/100g)	114.38±7.03	135.38±14.05
Zinc (mg/100g)	2.14±0.05	0.32± 0.01

Table 6. The ingredient compositions of concentrate feed (DM %).

Items	Ingredient compositions (%)
Corn grain	30.0
Wheat grain	16.5
Soybean meal	5.0
Wheat bran	10.0
Corn gluten feed	15.0
Cane molasses	3.5
Cottonseed hull pellet	4.0
Palm meal	10.0
Distillers grain	2.5
Salt dehydrated	0.6
Limestone	1.5
Vitamin premix	0.1
Mineral premix	0.1
Others	1.2
Total	100

as analysis samples. Samples were analyzed for DM, CP, NDF, ADF, EE, and CA according to methods of AOAC (2000). The mineral composition was analyzed from of the pre-treated samples using ICP (Inductively Coupled Plasma, Iris Intrepid, Thermo Elemental Co., UK). Free sugar was analyzed in the following order: exactly 5 g of sample was taken per Wilson et al. method (1981); 100 mL of 80% ethanol solution was added; sugar composition was extracted respectively for 2 hours at 80℃ from the heating mantle in the reflux cooling extraction unit; filtered by Whatman No. 5 and pre-treated; and was analyzed with HPLC analyzer (Waters 2414, Waters Co, USA) respectively. feed intake was calculated by determining the difference between the supplied and the remaining amount of feed, and the remaining feed was retrieved and measured before the feeding time the next morning. The average daily gain was calculated by subtracting the initial weight from the final weight of steers and then dividing by the duration of the experiments. In carcass evaluation, All steers were slaughtered after 24 h fasting. carcasses were chilled at 0 to 2℃ for 24 h and grade for meat yield and meat quality factors by trained personnel of Animal Products Grading Service in Seoul, Korea (APGS, 2009). Carcass weight, carcass yield, back fat thickness and *Longissimus* muscle area were assessed. Yield grade was classified with a scale of A, B or C. Quality grade was scored on a scale of 1^{++}, 1^{+}, 1, 2, and 3. Marbling score was evaluated with the Korean Beef Marbling Standard, and the scores of meat color and fat color were made using the color standard (APGS, 2009). And, marbling score was evaluated on a scale of 1 to 9, where 9 is very abundant and 1 is devoid. Fat color was score on a scale of 1 to 7, where 1 is white and 7 is yellow. meat color was scored on a scale of 1 to 7, where 1 is bright red and 7 is dark red. Texture was scored on a scale of 1 to 3, where 1 is good and 3 is bad. Maturity was scored on a scale of 1 to 3, where 1 is fine and 3 is coarse. Carcass grade was scored by combination of carcass yield grade and quality grade.

4. Statistical analysis

For statistical analysis of the result, analysis of variance was performed using the General Linear Model procedure of SAS (2002), and the significance for each treatment group was tested at the 5% significance level using Duncan's multiple range test.

Ⅲ. RESULT AND DISCUSSION

1. Feed intake and weight gain

Feed intake and body weight gain is shown in Table 7, and all experiment period for the treatment groups were 140 days. First see about the concentrate diet intake, C treatment had a total intake of 1,423.3 kg in the 140 days, T1 treatment had a total intake of 1,437.4 kg. T3 treatment had a total intake of 1,578.2 kg. Rice straw intake was done in limited feeding of 1 kg in each treatments so there were no differences. In the daily average intake (concentrate diet + rice straw) by treatments, T2 treatment showed a high intake of 12.3 kg while C treatment and T1 treatment showed low intake of 11.2, and 11.3 kg respectively. In the daily intake C and T1 treatment showed a 1.0~1.1 kg lower intake than T2 treatment. but there were not significant differences among treatments. Hatch and Beeson (1972), Copper et al. (1978) reported that including sugarcane molasses in the feed (less than 10%) increased digestibility digestion of dry matter, and increased intake volume due to this.

After the termination of the experiment, T2 treatment showed a high body weight of 711.7kg, compared to C treatment (681.0 kg) and T1 treatment (657.7 kg) ($p<0.05$). Total body weight gain during the experimentation period was the highest in T2 treatment with 99.0 kg and was lowest in T1 treatment with 77.3 kg, but there were no significant difference between treatments. This is due to the high different of total body weight gain among the experimental animals. Also, daily gain showed higher in order of T2 (0.70 kg) > C (0.61 kg) > T1 treatment (0.55 kg), there were no significant difference. In cold carcass weight T2 treatment showed a significantly ($p<0.05$) higher weight of 430.33 kg compared to C treatment (410.0 kg) and T1 treatment (390.7 kg). Result for cold carcass weight was similar to those of Kim (2006) and Lee et al. (2010), who reported that high live weight in carcass characteristics of Hanwoo steer had high dressing percentage.

However Kim et al. (2007) reported that even if the live weight is low, adding 1, 2, 3% mineral feed in comparison to the concentrate feed increased meat yield index. The reason why in this experimental results T2 treatment showed a high weight gain is because while lignin, cellulose, hemicellulose, and NDF was not properly digested or slowly digested in the rumen (Findlay, 1983), non-structural

Table 7. Dry matter intake and body weight gain

Items	Treatments		
	C	T1	T2
Feeding period (day)	140	140	140
Total feeding intake (kg of DM)	1,563.3	1,577.4	1,718.2
Concentrate (kg of DM)	1,423.3	1,437.4	1,578.2
Rice straw (kg of DM)	140.0	140.0	140.0
Feeding intake per day (kg of DM)	11.2	11.3	12.3
Initial body weight (kg)	595.6±19.4	580.3±17.0	612.7±29.0
Final body weight (kg)	681.0±25.4^{ab}	657.7±16.6^{b}	711.7±20.8^{a}
Body weight gain (kg)	85.3±6.5	77.3±10.21	99.0±19.7
Daily gain (kg)	0.61±0.05	0.55±0.08	0.70±0.14
Cold carcass weight (kg)	410.0±9.2^{ab}	390.7±22.1^{b}	430.3±5.9^{a}
Dressing percentage (%)	60.2±1.3	59.4±3.3	60.4±0.1

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

carbohydrates (non-fiber carbohydrates) like sugars were quickly digested in the rumen (Grant et al., 1995), and because adding black sugar (molasses) in the ruminate animal feed it increases palatability and improve rumen microbe growth (Emanuele, 2004). There were no differences in dressing percentage between C, T1, and T2 treatment.

2. Carcass yield grade and quality grade

The effects of addition of black sugar® and minerals® in the feed on meat yield and meat quality is shown on Table 8. Back fat thickness was C treatment 9.67 mm, T1 treatment 15.33 mm, and T2 treatment 14.33 mm, showing the order T1 > T2 > T3 treatment. However there were no significant differences. In the *longissimus* muscle area, while T2 treatment showed a high area of 88.33 cm^2, T1 treatment showed a low area of 81.67 cm^2, but there were no significant differences. It was estimated that this was because there was a high difference of back fat thickness and *longissimus* muscle area among the individual experimental animals. To resolve this problem it would be desirable to use ultrasound testing before experimentation to minimize back fat thickness and *longissimus* muscle area error range between each individuals to experimental animals. Meat yield grade was the highest in C treatment with 2.33 but in T1 and T2 it was low with 1.67. This results from the fact that back fat thickness in T1 and T2 treatment was higher compared to C treatment. Next, seeing the marbling score in the meat quality evaluation, C, T1, and T2 treatment showed 3.67, 4.67, and 5.67 respectively, showing the order T2 > T1 > C, with significant differences ($p<0.05$). Cho et al. (2000), Yang et al. (2000), and Kim et al. (2007) reported that adding minerals in the feed increased meat quality and heightened immunity, and reported that adding yellow soil, bentonite, and zeolite in ruminate animal feed, it results in meat quality improvement and prevention of loose stool and diarrhea because of the use of various mineral components (Rindsig et al., 1969; Martin et al., 1969; Britton et al., 1978; Milne and Froseth, 1982; Ivancic and Weiss, 2001; Kim et al., 2007). Lee et al. (2010) reported that adding bentonite in the Hanwoo steer finish fattening period showed improvement in meat quality but showed no significant differences.

In meat color, fat color, texture, and maturity there were no significant differences between C, T1, and T2 treatment. The reason why there were no differences in meat color,

Table 8. Meat characteristics of Hanwoo steers

Items	Treatments		
	C	T1	T2
Yield traits			
Back fat thickness (mm)	9.67±0.64	15.33±6.81	14.33±2.52
Longissimus muscle area (cm^2)	86.00±7.21	81.67±9.81	88.33±6.66
Yield grade[1)] (No.)	2.33±0.29	1.67±0.58	1.67±0.58
Quality traits			
Marbling score[2)]	3.67±0.58^b	4.67±0.75ab	5.67±0.38a
Meat color[3)]	5.00±0.00	5.00±0.00	5.00±0.00
Fat color[4)]	3.00±0.00	3.00±0.00	3.00±0.00
Texture[5)]	1.00±0.00	1.00±0.00	1.00±0.00
Maturity[6)]	2.00±0.00	2.00±0.00	2.00±0.00
Quality grade[7)]	2.83±0.29	3.33±0.58	3.67±0.28

Yield grade[1)] : 1 = C grade, 2 = B grade, 3 = A grade.
Marbling score[2)] : 1 = devoid, 9 = abundant.
Meat color[3)] : 1 = dark red, 7 = bright red.
Fat color[4)] : 1 = white, 7 = yellow.
Texture[5)] : 1 = good, 3 = bad.
Maturity[6)] : 1 = fine, 3 = coarse.
Quality grade[7)] : 1^{++} grade = 5 (best), 1^{+} grade = 4, 1grade = 3, 2grade = 2, 3grade = 1 (poor).
$^{a, b}$ Means in a row with different superscripts are significantly different ($p<0.05$).

fat color, texture, and maturity is because the breeding age is the same, addition feeding period is short at 140 days, amount of addition are low, and it was done in the finishing period and not the age where the effects of addition are more clear.

It was shown that meat quality grade was in the order T2 (3.67) > T1 (3.33) > C treatment (2.83), but there were no significant differences. However, referring to the results of the marbling score, it is thought that T1 and T2 treatment had a meat quality grade improvement over C treatment. And, it should be considered that mineral and black sugar addition for meat quality grade improvement needs additional experimentation with more detailed consideration of feeding period and feeding amount.

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