Effect of Sugar-Beet Pulp Supplementation on Fiber Degradation of Grass Hay in the Rumen of Goats

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ABSTRACT : This study was conducted to investigate the effects of four levels (0, 10, 20, 40 %) of sugar-beet pulp (SB pulp) supplementation to Italian ryegrass hay (IRG hay) on the fiber degradability of IRG hay in the rumen of goats. The following results were obtained: Degradabilities of DM, NDF, ADF and hemicellulose of IRG hay in the rumen increased significantly ($p<0.05$) by 10 % level supplementation of SB pulp to IRG hay. This was probably due to the increased numbers ($p<0.05$) of total viable bacteria, pectin-fermenting, xylan-fermenting and cellulolytic bacteria in the rumen in the increased supply of degradable pectic substances and hemicellulose at 10% level supplementation of SB pulp pectin. In 40% supplementation of SB pulp, ruminal pH was lowered by the fermentation of increased amount of molasses from SB pulp, resulting in the depression of growth of fiber fermenting bacteria and hence the decrease in degradabilities of cell wall fractions. It was suggested from this study that the sugar-beet pulp supplementation to forages at the level of 10% in the total diet increased fiber degradation of forage in the rumen of goats. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 2 : 186-188*)

Key Words : Sugar-Beet Pulp, Forage Fiber Degradation, Rumen Bacteria

INTRODUCTION

Sugar-beet pulp is widely used as a component of feed given to dairy cattle in Japan. Its high concentration of highly digestible fiber (Nocek and Russell, 1988; Carey et al., 1993; Tanaka et al., 1993; Stern et al., 1994; Zhao et al., 1996) makes a contribution to the increase in the milk fat content (Kelly, 1983; Valk et al., 1990; Visser et al., 1990; Mansfield et al., 1994; Sadoya et al., 1995) and in the efficiency of feed for producing 3.5% fat corrected milk (Mansfield et al., 1994).

In sugar-beet pulp supplementation to forage feeding, as in the usual practice, the highly digestible fiber supplied by sugar-beet pulp may have some effects on the degradation of forage fiber in the rumen. However, the feeding of readily fermentable fiber and pectin in sugar- beet pulp (Chester-Jones et al., 1990; Tanaka et al., 1993; Sadoya et al., 1995) might cause the change in rumen pH, which then might influence the activity of rumen microbes involved in the fiber degradation of forages (Obara et al., 1991). Thus, the level of supplementation is considered of primary importance in the feeding of sugar-beet pulp to ruminants. There are some studies on sugar-beet pulp supplementation dealing with alfalfa digestion in the rumen of dairy cows (Sievert and Shaver, 1993), digestion kinetics in beef steers fed brome hay (Carey et al., 1993), mixed feed digestion and microbial synthesis in steers (Zhao et al., 1996). In addition, studies with continuous culture fermenters dealt with bacterial synthesis and mixed feed digestion (Chester-Jones et al., 1990), and mixed feed digestion and rumen bacteria concentrations (Mansfield et al., 1994), bacterial nitrogen flow and mixed feed digestion (Stern et al., 1994). It does not seem, however, to be elucidated how the level of sugar-beet pulp supplementation influences the forage fiber degradation in the rumen and the activity of rumen microbes.

The present study was designed to investigate the effects of the level of sugar-beet pulp supplementation to grass hay on the degradability of fiber of the grass hay in the rumen, using the nylon bag technique, which was followed by being related to the number of rumen bacteria involved in the grass fiber degradation.

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Received January 12, 1998; Accepted August 31, 1998

MATERIALS AND METHODS

Animals and diets

Two ruminally fistulated Japanese Saanen female goats, weighing 55 kg and 60 kg, were used. The diets were Italian ryegrass hay (IRG hay) and sugar-beet pulp (SB pulp) which were mixed at various ratios, namely, IRG hay only (0B), IRG hay supplemented with SB pulp at the rate of 10% (10B), 20% (20B) or 40% (40B) of total weight of each diet. Each diet was adjusted to contain ca. 8% crude protein in the dry matter (DM) using soybean cake, before given to goats at the level of ca. 2% of body weight.

Experimental design

The period for feeding each diet was 19 days in the order of 0B, 10B, 20B and 40B. The diet was given to two goats once a day at 9:00 a.m. with free access to water and a mineral lick. Days 15, 16 and 19 were for the collection of rumen fluid, and Days 17-19 were for the measurement of degradabilities of IRG hay and cellulose powder using nylon bags suspended in the rumen for 48 hr.

Composition of rumen fluid

The rumen fluid was taken through the rumen cannula just prior to the diet feeding on each of Days 15 and 16. Rumen samples were strained immediately after collection through two layers of gauze for the

Table 1. Characteristics of four diets different in the content of sugar-beet (SB) pulp

	IRG hay[1]	SB pulp	SB pulp content in the diet			
			0% (0B)	10% (10B)	20% (20B)	40% (40B)
	(%)		(%)			
Crude protein	6.6	8.3	8.0[2]	8.0[2]	8.0[2]	8.0[2]
NDF	59.2	46.3	58.3	57.2	55.9	53.6
ADF	25.0	17.5	24.6	24.0	23.2	21.9
Hemicellulose	34.2	28.8	33.7	33.2	32.7	31.8

[1] Italian ryegrass hay. [2] Adjusted to 8% using soybean cake.

determination of microbial population. The numbers of total viable bacteria, pectin-fermenting bacteria, xylan-fermenting bacteria and cellulolytic bacteria were determined according to the method of Kajikawa and Minato (1990). At Day 19, rumen fluid was collected just prior to feeding in the morning for the measurement of pH.

Degradability in the rumen

Using the nylon bag technique (Mehrez and Ørskov, 1977), ca. 5 g DM of IRG hay or cellulose powder was put in a bag with a pore size of 50 μm. Four bags for each sample were put in the rumen of two goats just prior to the diet feeding in the morning and incubated for 48 hr (Days 17-19) for the determination of ruminal degradabilities of DM and fiber fractions. The fiber fractions of IRG hay sample were determined using the method of Goering and Van Soest (1970).

Statistical analysis

The experimental results were analyzed statistically by two-way analysis of variance using ANOVA.

RESULTS AND DISCUSSION

The characteristics of diets are shown in table 1. IRG hay was lower in CP content but higher in the contents of NDF, ADF and hemicellulose than SB pulp. Increasing the level of SB pulp supplementation to IRG hay decreased the contents of fiber fractions in the diet. Ruminal degradabilities of DM and fiber fractions of IRG hay are shown in table 2. Degradabilities of DM, NDF, ADF and hemicellulose in the rumen increased significantly ($p<0.05$) by 10% level supplementation of SE pulp to the control diet. However, significant decreases ($p<0.05$) were shown when SB pulp was added at the rate of 20 or 40%, except for hemicellulose degradability at 20% level supplementation. DM degradability of cellulose powder in the rumen increased greatly when the diet contained 10% level of SB pulp ($p<0.05$), followed by decreases in which DM degradability was still higher on the diet with 20% level supplementation ($p<0.05$) but was similar to that on the control diet when the addition level was 40% (table 2).

The ruminal pH is shown in table 3. The pH of

Table 2. Ruminal degradability of IRG hay and cellulose powder (Mean ± SD)

	SB pulp content in the diet			
	0% (0B)	10% (10B)	20% (20B)	40% (40B)
	(%)			
IRG hay				
DM	$59.4^{b}\pm1.04$	$62.4^{c}\pm1.44$	$57.2^{a}\pm0.28$	$56.3^{a}\pm0.80$
NDF	$51.4^{c}\pm1.25$	$55.2^{d}\pm1.72$	$48.8^{b}\pm0.31$	$46.2^{a}\pm0.99$
ADF	$23.4^{b}\pm1.96$	$29.6^{c}\pm2.71$	$19.1^{a}\pm0.49$	$17.0^{a}\pm1.54$
Hemicellulose	$88.9^{b}\pm0.29$	$89.5^{c}\pm0.41$	$88.5^{b}\pm0.07$	$85.3^{a}\pm0.26$
Cellulose powder				
DM	$69.2^{a}\pm2.53$	$86.0^{c}\pm1.50$	$73.2^{b}\pm1.44$	$69.4^{a}\pm1.04$

[a,b,c] Mean values with different superscripts in the same line differ dignificantly ($p<0.05$).

Table 3. Rumen fluid pH and the number of viable bacteria fermenting specific substrate (Mean ± SD)

	SB pulp content in the diet			
	0% (0B)	10% (10B)	20% (20B)	40% (40B)
Rumen fluid pH	$6.56^{b}\pm0.14$	$6.61^{b}\pm0.26$	$6.56^{b}\pm0.25$	$6.08^{a}\pm0.18$
	($\times 10^{8}$/ml)			
Total viable bacteria	$26.2^{c}\pm1.44$	$27.3^{c}\pm2.61$	$22.5^{b}\pm1.45$	$17.3^{a}\pm0.74$
Pectin-fermenting bacteria	$10.4^{b}\pm0.87$	$16.7^{d}\pm0.64$	$12.5^{c}\pm1.28$	$3.6^{a}\pm0.10$
Xylan-fermenting bacteria	$7.0^{b}\pm1.01$	$8.3^{c}\pm0.12$	$8.2^{c}\pm0.31$	$2.9^{a}\pm0.10$
Cellulolytic bacteria	$0.39^{b}\pm0.02$	$1.07^{d}\pm0.15$	$0.75^{c}\pm0.06$	$0.24^{a}\pm0.01$

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

rumen fluids showed little differences when the SE pulp supplementation level was from 0% to 20%, but it decreased significantly ($p<0.05$) by the 40 % level addition in the diet. This reduction in pH on the 40B diet might be brought about partly by the fermentation of increased amount of molasses by the supplied pellets of SB pulp. The microbial population in the rumen fluid is shown in table 3. The numbers of pectin-fermenting, xylan-fermenting and cellulolytic bacteria significantly increased when the 10B diet was fed to goats ($p<0.05$). When the 20B diet was fed, pectin-fermenting, xylan-fermenting and cellulolytic bacteria increased in the numbers ($p<0.05$), but there was a reduction in the numbers of total viable bacteria ($p<0.05$). Feeding the 40B diet resulted in large reductions in the numbers of rumen bacteria counted in the present investigation ($p<0.05$). The improvement in the degradation of cellulose (table 2) by the proliferation of cellulolytic bacteria (table 3) might be associated with the increased numbers of pectin- and xylan-fermenting bacteria (table 3), which was probably due to the increased supply of degradable pectic substances and hemicellulose in the supply of 10% level of SB pulp pectin (10B diet). It is likely that some species of hemicellulose fermenter which increased in the number are also cellulose degraders (Fahey and Berger, 1988). The lowered pH on the 40B diet may be one of the reasons for the depression of growth of fiber fermenting bacteria and hence the decrease in degradabilities of cell wall fractions. These results suggest that the similar phenomenon in feeding starch-rich diet recognized as 'starch depression' might occur under the feeding of larger amount of highly digestible fiber.

In conclusion, the sugar-beet pulp supplementation to forages at the level of 10% in the total feed increased fiber degradation of forage in the rumen of goats. As some depression of fiber degradation was observed at the higher level of supplementation, further investigations will be needed for the most effective level for the proliferation of cellulolytic bacteria.

ACKNOWLEDGEMENTS

We wish to thank Mr. Y. Yano for his skilled technical assistance in this work.

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