STUDY ON THE UTILIZATION OF RICE STRAW BY SHEEP
2. THE EFFECT OF SOYBEAN MEAL SUPPLEMENTATION ON THE EATING AND RUMINATION BEHAVIOR

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Summary

Three Japanese Corriedale wethers were used in a 3 × 3 latin square design to determine the effect of soybean meal (SBM) supplementation on the eating and rumination behavior in sheep fed rice straw as a basal diet. Soybean meal was supplemented at three levels of 0 (control), 75 g and 150 g/day. Soybean meal supplementation had no significant effect on the daily time spent eating and rumination, whereas the rate of eating of rice straw was significantly faster ($p < 0.05$) in sheep fed SBM-supplemented diets than in sheep fed control diet. However, when expressed per 100 g of neutral detergent fibre (NDF) intake, daily rumination time of sheep fed 75 and 150 g of SBM-supplemented diets was greatly reduced ($p < 0.01$). The length of each rumination period, daily number of rumination periods and number of boli regurgitated were about constant for all SBM levels. Cyclic rate (rumination time per daily number of boli regurgitated) and rumination index (rumination time per 100 g of dry matter eaten) were significantly decreased ($p < 0.05$) by SBM supplementation. The number of chews per bolus was not affected, whereas the bolus time reduced ($p < 0.05$) and the rate of chewing during rumination was increased ($p < 0.05$) by SBM supplementation.
(**Key Words**: Rice Straw, Soybean Meal, Eating and Rumination Behavior)

Introduction

There are many factors involving in the regulation of intake and utilization of low quality roughage by ruminants. It is also well known that nitrogen is the main limiting factor in the utilization of the roughage as a source of feed for ruminant animals, and protein supplementation undoubtedly could improve its voluntary intake and digestibility as reported by Church and Santos (1981) and Guthrie and Wagner (1988). However, physical factors such as the capacity of reticulo-rumen and the rate of removal of digesta from this organ also limit the intake of low quality roughages (Campling, 1969). Furthermore, the rate of passage of digesta from the rumen is dependent on its rate of breakdown in the rumen by microbial attack and by mechanical process (chewing during eating and rumination) until the particles size of digesta become small enough to pass through reticulo-omasal orifice. Considerable experiments have been done in this aspect; however, there are few reports relating protein supplementation to the pattern of eating and rumination. It is expected that soybean meal (SBM) supplementation to rice straw diets could improve the activity of rumen microorganisms, thus should affect the rumination behavior. Objective of this study was to examine the effect of SBM supplementation on the eating and rumination behavior in sheep fed rice straw as a basal diet.

Materials and Methods

Animal management and experimental diets

Three Japanese Corriedale wethers, with an initial body weight (mean ± SD) of 42 ± 3.5 kg were used in a 3 × 3 latin square design. They were kept in individual cages throughout the experimental periods and each animal was fed with one of the three treatment diets as follows : ① rice straw alone (control), ② rice straw + 75 g SBM/day (0.18% of BW), and ③ rice straw + 150 g SBM/day (0.36% of BW). Before

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starting the experiment, all sheep were treated with "Thybenzole 75%" (90 mg/kg BW) to control gastro-intestinal roundworms. The chemical composition of rice straw was 82.3% organic matter (OM), 3.6% crude protein (CP), 73.8% neutral detergent fibre (NDF), and 55.5% acid detergent fibre (ADF). Soybean meal used in this study contained 93.1% OM and 44.3% CP. The rice straw was chopped into 1~2 cm length and was offered *ad libitum,* i.e. 25% greater than the amount on the previous day consumed. The daily allowance of rice straw and soybean meal was given in two equal portions at 09:00 and 17:00 h. Drinking water and mineralized block salt were freely available. Refused rice straw was removed and weighed everyday just before morning feeding. In addition, there was no residue obtained from the supplement throughout the experimental period.

Determination of the eating and rumination characteristics

The characteristics of eating and rumination behavior were determined continuously for 5 consecutive days, using a wire strain gauge attached on the lower jaw of animals according to the procedure described by Harumoto and Kato (1978). The jaw movements were recorded by a pen recording chart, in which the chart speed was maintained at 1 cm/minute throughout the recording periods, except for a day of determination of number of chewing per bolus, where speed was increased to 6 cm/minute. Parameters of eating and rumination observed were daily eating and rumination times, rate of eating, daily number of rumination periods, rumination index, and bolus and chewing characteristics during rumination (Fujihara, 1980).

Statistical analysis

All data were subjected to analysis of variance for a 3×3 latin square, and difference among the treatment means were determined by the least significant difference method (Steel and Torrie, 1981).

Results and Discussion

Data pertaining to the rice straw intake, eating and rumination activities of sheep for each treatment are presented in table 1. Voluntary intake of rice straw significantly increased ($p < 0.05$) in sheep given 75 and 150 g of SBM-supplemented diets than that in sheep given a rice straw alone. However, the daily time spent eating and rumination were not significantly affected by SBM supplementation. Consequently, the eating rate of rice straw in the supplemented sheep was higher ($p < 0.05$) than that of unsupplemented ones. These findings support the previous results of Freer et al. (1962), who reported that the time spent eating and rumination in cows fed oat straw *ad libitum* were not influenced by urea administration, but when expressed per unit straw intake, the time spent rumination decreased. Harumoto and Kato (1979) showed that when wheat bran was added to rice straw diets, rumination time varied considerably between the treatment sheep, but the eating rate of rice straw significantly increased. The daily rumination time of sheep fed a rice straw alone in this study was 611

TABLE 1. EFFECT OF SOYBEAN MEAL SUPPLEMENTATION ON THE VOLUNTARY INTAKE OF RICE STRAW AND EATING AND RUMINATION ACTIVITIES IN SHEEP FED RICE STRAW AS A BASAL DIET

Item	Level of soybean meal (g/d)			SEM[1]
	0	75	150	
Rice straw intake (g/day)	540.4[a]	791.7[b]	794.4[b]	53.4
Eating time (min/day)	305.4	365.9	360.6	26.2
Eating rate (g DM/min)	1.8[a]	2.2[b]	2.2[b]	0.05
Rumination time (min/day)	610.8	532.7	503.9	56.6
Rumination index[2]	112.5[c]	67.2[d]	63.9[d]	5.2
Rumination time (min/100 g NDF intake)	152.4[c]	89.6[d]	83.8[d]	6.0

[abcd] Values in the same row with different superscripts differ significantly (a,b: $p < 0.05$; c,d: $p < 0.01$).

[1] Standard error of the mean.

[2] Time spent rumination per 100 g dry matter intake.

minutes. This value apparently indicate the maximum time spent ruminating of ruminants (approximately 10 h/day) as suggested by Weston (1982).

Rumination index (daily time spent rumination per 100 g dry matter eaten), which indicate the work done by ruminants in comminuting ingested diet (Fujihara, 1981), was considerably reduced by SBM supplementation. Moreover, when expressed per 100 g NDF intake, rumination time was also remarkably shorter ($p < 0.01$) with SBM-supplemented diets as compared to unsupplemented ones. These results suggest that reduction of digesta particles size by microbial activities improved as increasing levels of SBM in the diets. Thus, sheep required less rumination time for comminution of ingested diets to pass through the reticulo-omasal orifice. The fact that eating rate of rice straw was faster on the supplemented sheep lead to the suggestion that sheep used less energy during eating, as proposed by Osuji et al. (1975). He reported that when animal fed slowly, the energy cost per unit dry matter intake will be increased, and vice versa.

As shown in table 2, the length of rumination period, daily number of rumination periods and number of boli per rumination period were almost constant for each treatment. These results are in agreement with the previous experiment of Fujihara and Nakao (1984), who reported that

TABLE 2. EFFECT OF SOYBEAN MEAL SUPPLEMENTATION ON THE RUMINATION PERIOD TIME, DAILY NUMBER OF RUMINATION PERIODS AND NUMBER OF BOLI PER RUMINATION PERIOD IN SHEEP FED RICE STRAW AS A BASAL DIET

Item	Level of soybean meal (g/d)			SEM[1]
	0	75	150	
Time spent per rumination period (min)	34.1	31.8	29.4	8.6
Daily number of rumination periods	18.5	18.5	18.3	3.8
Number of boli per rumination period	29.0	32.0	31.6	10.2

[1] Standard error of the mean.

increasing levels of casein supplement to hay diet did not affect those parameters in sheep. According to Harumoto and Kato (1979), daily number of rumination period is relatively stable parameter in the rumination behavior of sheep.

Daily number of boli regurgitated was not influenced by SBM supplementation (figure 1a). However, the cyclic rate (time spent rumination per daily number of boli regurgitated) was significantly shorter in sheep fed SBM-supplemented diets as compared with sheep fed a rice straw alone (figure 1b). This finding suggests that motility of reticulo-rumen might be increased by SBM supplement. Fujihara and Nakao (1984), obtained that both number of boli regurgitated and cyclic rate were not affected by casein supplementation in sheep given hay diet. This difference was probably caused by a difference in feed and supplement, and partly by physical effect of SBM and individual variations between sheep used.

Fujihara (1980) has used the number of chews per bolus, bolus time, and chewing rate charac-

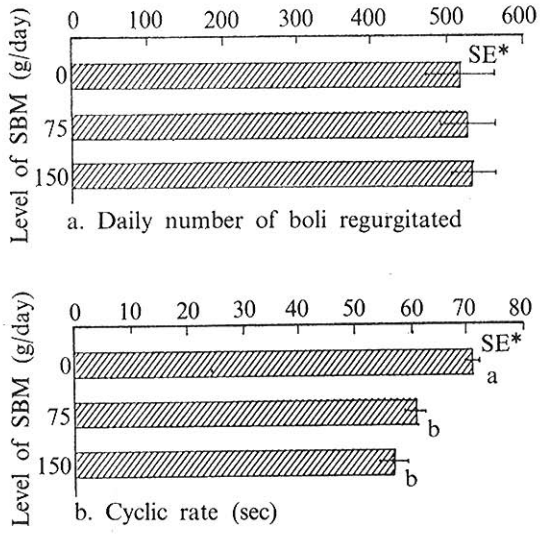

Figure 1. Daily number of boli regurgitated and cyclic rate in sheep fed rice straw supplemented with various levels of soybean meal (SBM).
* Standard error.
ab: Significantly difference ($p < 0.05$).

teristics in order to estimate the quality of rumination. In this study, the bolus time was significantly shorter ($p < 0.05$) (figure 2a), and the number of chews per bolus tended to be reduced (figure 2b) as increasing level of SBM supplementation. The chewing rate (number of chews per minute during rumination) was also significantly faster ($p < 0.05$) in the supplemented sheep than that in unsupplemented ones (figure 2c). These results should indicate that the rumination activity was less intensive in sheep given SBM-supplemented diets than in sheep given a rice straw alone. From the results obtained in this study, it can be concluded that SBM supplementation to rice straw diets clearly altered the eating and rumination behavior in sheep. However, to understand more detail mechanisms involved, further study on the changes of digesta particles size and its passage from the rumen is needed.

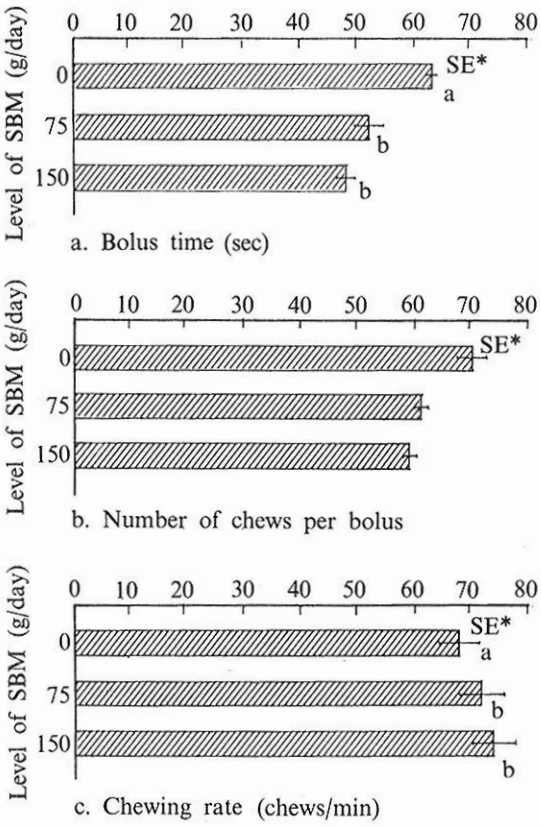

Figure 2. The bolus time, number of chews per bolus and chewing rate in sheep fed rice straw supplemented with various levels of soybean meal (SBM).
* Standard error.
ab: significantly difference ($p < 0.05$).

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