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The Eating and Rumination Behaviour in Sheep Fed only Corn Silage*

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青刈トウモロコシサイレージ給与時におけるメンヨウの採食・反芻行動について

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Summary

The eating and rumination behaviour was investigated in sheep fed only corn silage diet (A, B or C) which was made in different year and the following results were obtained.

1) The time spent eating silage B was fairly long, but not significantly, as compared with that in silages A and C, and consequently, the eating rate with silage B was markedly slower than those with silages A and C. The rumination appearance (lag time after feeding) was fairly shorter with silage C than with silages A and B, but not significantly because there was a quite large variation between individuals.

2) Daily time spent ruminating tended to be longer after feeding silage C than after feeding of silage A or B. The daily number of rumination periods was slightly more with silage C than with silages A and B, and cyclic rate was clearly longer with silage C than with silages A and B.

3) In rumination efficiency, rumination index (time spent ruminating/100 g D. M. eaten) was significantly high in silage A feeding as compared with those in feedings of silages B and C. Bolus time was clearly longer with silage C than those with silages A and B. The rumination chewing rate was significantly higher in feeding of silage A than in feedings of silages B and C. These findings obviously suggest that the quality of silages clearly influence the rumination behaviour, especially on rumination index and chewing rate during rumination.

Introduction

It is clear in ruminant animals that eating and rumination behaviour is considered to be an important function related to the utilization of roughage feed.[1-4] It has been also shown that the physical form and/or chemical composition of feed, in particular

* Studies on the roughage utilization in sheep. No. 7.

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roughages, considerably affects eating and rumination behaviour.[5-8] It has been suggested that the rumination of sheep is more intensive and efficient in the case of fresh-grass feeding than in hay feeding,[9] and furthermore, it has been also confirmed that the difference in physical form property of fresh-grass and hay (or dried-grass) caused by moisture content might considerably affects eating and rumination behaviour in sheep.[10] These findings might suggest that water consumption with roughage feed (as moisture) clearly influence the eating and rumination behaviour in ruminants.

According to Campling,[11] the eating and ruminating time per kg in cows was longer in silage feeding than in hay feeding when the silage and hay were made of forage harvested from the same pasture, though the voluntary dry matter intake was smallr (28%) in silage feeding than in hay feeding. In our previous experiments,[4,12] the time spent eating and ruminating in sheep tended to small after feeding silage made from the fibrous residues of legumes as compared with that after feeding grass hay. On the other hand, the time spent ruminating was fairly prolonged after feeding the mixed ration of legume residue-silage and hay in equal amount of dry matter.[12] It appears that the eating and rumination behaviour has no definite trend in the feeding of an ensiled materials in cows and sheep.

Relatively little work has been reported on eating and rumination behaviour in relation to the quality of corn silage, although it has been discussed when cows were fed the diet of corn silage with some kinds of concentrates.[13] The present paper shows the results summerized the data obtained during the digestion trials conducted in three consecutive years with sheep fed only a corn silage.

Materials and Methods

Animals and diets

Five Japanese Corriedale male sheep (nos. k433, k468, k790, k897 and 531), each weighing 31-38 kg, were used repeatedly. These sheep were allocated for the three feeding treatments as follows; Silage A, k433, k468 and k897; silage B, k468, k790 and k897; silage C, k433, k790 and 531, respectively.

The silages A, B and C were made on a summer season in 1980, 1981 and 1982, respectively. The yellow corn* was cultivated on the same experimental field of Shimane University, and was harvested at almost the same stage (heading) in each

Table 1. Chemical composition of diet

	Moisture	pH	Organic matter	Crude protein	Crude fat	Crude fibre	NFE*
Silage A	90.0	4.60	86.1**	10.1	3.7	33.7	38.6
Silage B	90.4	4.77	85.5	14.8	4.2	35.4	31.1
Silage C	86.0	4.70	87.9	10.4	3.2	31.7	42.7

* Nitrogen free extract.
** % of dry matter.

* Yukijirushi Co. Ltd. Sapporo-shi, Hokkaido, Japan

year. Before ensiling, the herbage was slightly dried for 5–6 hours on the field, and was cut 2–3 cm long. After ensiled for 2–3 months, each silage was used for feeding experiment in each year. The chemical composition (as % of dry matter) of silages, determined by the method of AOAC[14], is shown in Table 1.

Experimental procedure

The sheep were kept in the metabolism cages throughout the experimental period. Five-day sampling periods were preceded by 7-day preliminary periods. Each sheep was offered a diet in which the dry matter was 2.0% of body weight per day. One-half of the daily ration was given at 09 : 00 hour and the another half at 17 : 00 hour. During the 5-day sampling period the time spent chewing during eating and ruminating was measured daily by the method of Fujihara[9] using a wire strain gauge on the lower jaw.[15] The terms used for indicating the rumination behaviour is the same as in a previous report of Fujihara[9] based on the work of Gordon.[16] The statistical analysis of the data was made by t-test.[17]

Results and Discussion

As shown in Table 1, moisture content of silages was 86–90%, and these values were very similar to those of silages made from the fibrous residues of legume plants,[18-20] and were fairly high as compared with that of corn silage used in general. The pH values were 4.6–4.7, and these were fairly high as compared with those of eansiled fibrous residues of legumes (3.75–4.47) as reported earlier.[18-20] Organic matter contents were roughly 5–6% lower than those of ensiled fibrous residues of legumes.[18-20] The crude protein content in silage B was slightly higher than those in silages A and C,

Table 2. Eating behaviour and the lag time after eating in sheep fed only corn silage

Diet	Silage A (3)*	Silage B (3)	Silage C (3)
Time spent eating(min)	184.6±61.6**	250.7±35.3	212.2±15.3
Rate of eating(g D.M./min)	2.5± 0.3^{ab}	2.1± 0.3^{a}	3.1± 0.4^{b}
Rumination appearance(min)***	108.9±46.0	127.2±78.0	78.0± 7.6

* Number of sheep used.
** Mean±S. E. of 3 sheep.
*** Time after eating.
a-b Means within columns with different superscript letters are significantly different ($P<0.05$).

and the values shown in Table 1 were quite low as Compared with those of ensiled fibrous residues of legumes as reported previously.[18-20] The contents of crude fibre and nitrogen free extract (NFE) were almost similar to those of ensiled fibrous residues of legume plants.[18-20] On the whole, the nutrient contents of the silages used here were almost the same as that of corn silage used generally.[21]

Table 2 shows the eating behaviour and rumination appearance (lag time after eating) in sheep fed only corn silage. Daily time spent eating silage B was slightly

Table 3. Rumination behaviour in sheep fed only corn silage

Diet	Silage A (3)*	Silage B (3)	Silage C (3)
Daily time spent ruminating(min)	504.0±20.5^{ab}**	471.9±28.6^{a}	560.4±7.7^{b}
Daily no. of boli regurgita ted	574.6±44.5	544.2±39.2	549.8±27.9
Daily no. of rumination periods	16.9± 3.0	17.8± 2.7	20.8± 0.7
Cyclic rate(sec)***	53.0± 2.3^{a}	52.2± 1.9^{a}	61.4± 2.9^{b}
Time spent per rumination period(min)	32.7± 8.3	28.4± 6.7	27.0± 1.4
No. of boli per rumination period	37.7±10.5	32.8± 7.6	26.5± 2.0

* Number of sheep used.
** Mean±S. E. of 3 sheep.
*** Total rumination time/no. of boli requrgitated (Gordon, 1961).
a-b Means within columns with different superscript letters are significantly different ($P<0.05$).

longer than those with silages A and C, but not significantly because a quite large variation between animals. Avergage time spent eating observed in this experiment was similar to those with timothy hay[12] and low quality mixed hays,[22,23] and was 2-3 times long as compared with those after feeding the ensiled fibrous residues of legume plants as mentioned earlier.[4,12] The rate of eating was significantly higher with silage C than those with silages A and B, although there was no significant difference of time spent eating between silage C and silage A or B. Rumination appearance tended to be shorter in feeding of silage C than in feeding of silage A or B, and there was some differences of lag time among experimental animals. There were also large variations of lag time after feeding of hay in our previous experiments using sheep.[10,24] The values shown in Table 2 were in a range observed in our previous study using sheep fed only hay diet or drifd grass diet.[10,22,23]

Table 3 shows the rumination behaviour in sheep fed only diet of ensiled corn. Daily time spent ruminating was remarkably shorter with dilage B than with silages A and C, and this may be due to a difference of silage quality. As shown in Table 1, the fibre content, as it seems to be a factor affecting rumination behaviour,[25] was rather higher in silage B than those in silages A and C. It is also shown that there is a close relationship between the time spent ruminating and the quality of dietary fibre (ADF and/or NDF).[26] Therefore, it may be assumed that the quality of dietary

Table 4. Rumination efficiency in sheep fed onlycorn silage

Diet	Silage A (3)*	Silage B (3)	Silage C (3)
Rumination index**	120.3±10.0^{a}***	93.0±6.6^{b}	87.1±3.9^{b}
No. of chewsr pe bolus	56.8± 8.3	50.4±3.3	57.8±5.1
Bolus time(sec)	40.3±8.5^{ab}	41.0±1.5^{a}	49.2±2.1^{b}
Rumination chewing rate/min	88.4±6.0^{a}	73.6±2.5^{b}	70.2±3.4^{b}

* Number of sheep used.
** Time spent ruminating per 100 g D. M. eaten(Fujihara, 1980)
*** Mean±S. E. of 3 sheep.
a-b Means within columns with different superscript letters are significantly different ($P<0.05$).

fibre was quite different in silage B feeding and in feedings of silages A and C, and there was also same trend between silage A feeding and silage C feeding, although the quality of dietary fibre (ADF and NDF contents) was not clarified in the present experiment.

Daily time spent ruminating observed in the present study was very close to those observed in sheep fed only diet of fresh forage[27] or medium hays[22,23] at same feeding level. The sheep, however, was needed to spend a long time for ruminating as compared with those used in experiment with silages made from the fibrous residues of legume plants reported earlier.[4,12]

Daily number of boli regurgitated was almost the same with all the silage diets, and the values were very close to those reported earlier,[9] in which sheep were given only fresh grass or hay diet. Daily number of rumination period was also similar in all the diets, and the values were in a range observed in sheep offered only forage diet as mentioned earlier.[27] Cyclic rate[16] after feeding silage C was significantly slower than those after feeding of silage A or B, this would be due to a difference in crude fibre content of diet. According to our previous result,[27] it has been shown that cyclic rate tended to slow with a decrease of dietary fibre in sheep fed only fresh forages. The time spent ruminating and number of boli per rumination period did not change with a change of diet of silage.

The Table 4 shows the rumination efficiency in sheep fed only corn silage diet. The rumination index, as time spent ruminating/100 g D. M. eaten,[9] was significantly greater with silage A than those with silages B and C. This indicates that the sheep needed a long time for comminuting dietary particles after feeding silage A as compared with that after feedings of silages B and C. The rumination efficiency was estimated by measureing the number of chews per bolus, bolus time (average time in seconds spent chewing per bolus) and the chewing rate during ruminating. The number of chews per bolus after feeding silage B was slightly small, but not significantly, as compared with those after feeding silage A or C. The bolus time with silage C was significantly longer than that with silage B, and in comparison with that in feeding of silages A and C, there was no significant different, although there was a trend to decrease bolus time after feeding silage A. The rumination chewing rate was significantly higher with silage A than those with silages B and C, and this clearly indicate that sheep did ruminate more efficiently after feeding silage A than after feeding of silages B and C. These findings also indicate that the sheep did chew more slowly during rumination when they were offered silage B or C than when offered silage A, and these differences in chewing behaviour would reflect some differences in chemical composition of silages as diet, which could not be shown in Table 1 as mentioned above, such as a quality of dietary fibre. These results were clearly reflected on the significant differences in digestibilities of the nutrients except crude fibre,[28] that is, digestibility coefficients of organic matter, crude prctein, crude fat and NFE were significantly lower in silage A than in silages B and C. These

findings about rumination behaviour might suggest that the quality of ensiled corn, as well as other roughages, clearly affect the rumination, especially on rumination index and chewing rate during rumination.

From the results obtained in this study, it was shown that eating and rumination behaviour in sheep fed only ensiled corn does not differ largely from those in sheep fed only other roughage feeds such as fresh forages or hays at a similar feeding level.

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摘　　要

本実験ではサイレージ給与時におけるメンヨウの採食・反芻行動について詳細に検討するため，製造年（1980～1982年）の異なる3種類の青刈トウモロコシサイレージ（A，B，C）を用いて消化試験を行い，次の様な結果を得た．尚トウモロコシは各年共，同一圃場で栽培し，ほぼ同一時期に播種，収穫及びサイレージ調製を行った．

1）各サイレージ共，採食量はほぼ同様であったが，採食時間はサイレージB給与時でかなり長くなり，その結果，採食速度はサイレージA及びC給与時に比して著しく遅くなった．採食終了後反芻発現までの時間はサイレージC給与時で他に比べてかなり短くなったが，個体間の変動も大きく統計的な有意差とはならなかった．

2）一日当りの反芻時間はサイレージC給与時で他に比べて著しく長くなり，サイレージB給与時との間では統計的に有意な差（$P<0.05\%$）となった．一日当りの反芻期数はサイレージC給与時で他に比べて若干多くなる傾向にあり，吐出周期も明らかに長くなった．

3）反芻効率についてみると，Rumination Index（摂取乾物 100g 当りの反芻時間）はサイレージA給与時で他に比べて有意に長くなった．一吐出当りの反芻時間はサイレージC給与時では他に比べて明らかに長くなる傾向があった．反芻時の再咀しゃく速度はサイレージA給与時ではサイレージBとC給与時より有意に（$P<0.05$）遅くなった．

これらの結果はコーンサイレージの質（特に粗繊維の質）は明らかに反芻行動，特に Rumination Index と反芻時の再咀しゃく速度に影響を及ぼすという事を示唆した．