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THE FEED VALUE OF ENSILED CORN IN SHEEP*

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トウモロコシサイレージのヒツジにおける利用性について

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Abstract

The nutritive value of corn silages was examined in digestion and nitrogen balance trials using sheep fed the silage alone at about 2.0% level of dry matter (DM) per kg body weight which conducted during 3 consecutive years. The results obtained were as follows;

1. The apparent digestibilities of nutrients tended to be higher in silage feeding than in feeding of timothy hay as a control roughage, although there was a little difference of the values among silages.
2. Urinary nitrogen excretion tended to be high in feeding of silage compared with that in hay feeding, and consequently, negative nitrogen balance was observed in silage feeding although nitrogen intake was almost similar in both feedings of silage and hay.
3. Ruminal ammonia concentration was fairly higher in silage feeding than in hay feeding, and the level of VFAs in rumen fluid was almost the same in both feedings of silage and hay.
4. The concentrations of glucose and urea nitrogen in the blood were almost similar in both feedings of silage and hay, and the plasma protein level was also similar in the feedings of silages and hay.

From the obtained results, it was obviously concluded that ensiled corn can be utilized as a roughage feed in sheep as well as in cattle which have been accepted generally.

Introduction

The ensiling technique is the most popular method for conservation of fresh forages, and a corn silage is very common feed for ruminants, in particular for dairy cow, in winter season. In general, corn silage, so called whole crop silage, is made from a corn plant of mostly mature stage to increase the dry matter yield and/or to reduce the moisture content of ensiled material. As it is well known, however, a digestible nutrient of forage is clearly decreased with a progress of its growth stage,[1] and is also changed according to the growing condition.

On the feeding of corn silage, it may be usual that the animal ordinary receive the silage with other additional feed such as some concentrates,[2] because it is obvious that the dry matter intake by animal is quite low in feeding ensiled materials.[3] As things stand now, the investigation about food value of corn silage when it was given alone to sheep seems to be not so much contrary to our expectations.[3] In the series of experiments on roughage utilization in sheep, we have already reported the eating and rumination behaviour in sheep fed a corn silage alone.[4] In this paper, the nutritive value of ensiled corn is dicussed using the data obtained

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in the digestion and balance trials conducted during consecutive 3 years in sheep fed the ensiled corn alone.

Experimental procedure

Animals and diets were as described previously.[4] Five Japanese Corriedale male sheep, each weighing 31–38 kg, were used repeatedly. Three corn silages, *i. e.*, A, B and C, were made on a summer season in 3 consecutive years as mentioned earlier.[4] The chemical composition (as % of dry matter) of silages A, B and C, determined by the method of AOAC,[5] was: organic matter, 86.1, 85.5 and 87.9; crude protein, 10.1, 14.8 and 10.4; crude fat, 3.7, 4.2 and 3.2; crude fibre, 33.7, 35.4 and 31.7; nitrogen free extract (NFE), 38.6, 31.1 and 42.7, respectively.

The sheep were kept in the metabolism cages throughout the experimental period. Three sheep were allocated for the 3 feeding treatments, and each sheep was offered a diet of silage in which the dry matter was about 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. Five day sampling periods were preceded by 7-day preliminary periods. Faeces and urine were collected daily just before the morning feed during sampling period. On the final day of each trial, about 100 ml of rumen contents were sampled using stomach tube at 09:00, 10:00, 11:00, 12:00, 14:00 and 16:00 hour, and the pH value and the concentrations of ammonia and VFAs of rumen fluid were measured. Similarly, about 5 ml of jagular blood was collected at 09:00, 12:00, 14:00 and 16:00 hour on the final day of each trial, and glucose, blood urea-nitrogen and plasma total protein were determined. The other experimental procedures were as described earlier.[5] The statistical analysis of the data was made by *t*-test.[7]

Results and Discussion

As mentioned previously,[4] moisture content (86−90%) of silages used in this study was very similar to those of silages made from the fibrous residues of legume plants,[6,8,9] though that were fairly high as compared with that of corn silage used in general.[10] As a whole, however, the nutrient contents (dry matter basis) of the silages used here were almost the same as that of corn silage used generally.[10]

Table 1 shows the apparent digestibility and nitrogen balance in sheep fed the silage and hay. The digestibility of organic matter of silage A was significantly lower than those of silages B and C, and was also slightly lower than that of timothy hay as control diet. The values with silages B and C were very similar to that of silage made from the fibrous residue of broad bean,[9] and were fairly lower than that of the silage made from the fibrous residue of ladino clover,[8] as described in our previous publications. Crude protein digestibility of silage A was also significantly lower than those of silages B and C, and was also fairly lower than that of hay. In general, apparent digestibility of crude protein in ruminant obviously lower with decrease of intake of dietary protein, if the quality of dietary protein is almost the same grade. The digestibilities of crude protein with silages B and C were very comparable to those with the silages made from fibrous residue of ladino clover,[8] and the value with silage A was similar to that with the silage made from fibrous residue of broad bean.[9] The content of crude protein of silage A was almost

Table 1. Apparent digestibility and nitrogen balance

Diet	Silage A (3)#	Silage B (3)	Silage C (3)	Hay* (3)
Apparent digestibility,				
Organic matter	46.2±2.9a**	58.5±2.4b	60.4±1.6b	53.5
Crude protein	40.8±7.1a	67.5±1.5b	64.0±1.5b	60.7
Crude fat	55.1±4.9a	70.5±1.7b	79.9±3.9c	56.8
Crude fibre	55.5±4.3	64.6±2.8	62.6±1.9	55.8
Nitrogen free extract	39.0±1.2a	45.4±2.6ab	56.5±1.8b	50.2
Nitrogen balance (g/kg B.W.$^{0.75}$)				
Intake	0.49±0.03	0.89±0.05	0.70±0.03	0.70
Faecal	0.29±0.04	0.29±0.01	0.25±0.01	0.27
Urinary	0.45±0.25	0.63±0.05	0.50±0.04	0.39
Retention	−0.33±0.30	−0.03±0.02	−0.05±0.04	0.04

* Timothy hay as a reference (see Fujihara & Ohshima, 1982).
** Mean ± S.E. of 3 sheep.
# Number of sheep used.
a-c Means not having the same superscript letters are significantly different at 1−5% level.

the same as that of silage C, but there was a quite big difference in digestibility of crude protein in feedings of both silages. This might be due to a difference in quality of silages A and C, such as a difference in growth stage of the corn ensiled, and subsequent a lower intake of silage A, because it is clear that the digestible nutrients of forages is decreased with a progress of their growth stage.[1] Crude fat of silages B and C were significantly more digestible than that of silage A and timothy hay as a reference, and was very similar to that of the silage made from fibrous residue of broad bean.[9] In our previous report,[6,8] it has been shown that the digestibility of crude fat in silage made from the fibrous residue of ladino clover was about 40−60% with untreated one and 57% with another one treated by formaldehyde and formic acid, although there were no big difference in their crude fat contents. The crude fibre digestibility of silage A was a little lower than those of silages B and C, but not significantly. The values with silages B and C are still quite lower than those with silages made from the fibrous residue of ladino clover as described earlier,[6,8] and are very comparable to that of silage made from the fibrous residue of broad bean.[9] The digestibility of NFE was very low in silage A as compared with those in silages B and C, and these figures are very lower

Table 2. Ruminal pH and the concentrations of ammonia and VFAs in rumen fluid of sheep fed silage diets

	Silage A (3)#	Silage B (3)	Silage C (3)	Hay* (3)
pH	6.95±0.01**	7.11±0.05	−	7.43
Ammonia (mg/100 ml)	12.38±2.05	11.60±2.70	−	7.11
VFAs (mM/100 ml)	5.97±0.89	6.98±0.41	6.45±0.69	5.68

* Timothy hay as a reference (see Fujihara & Ohshima, 1982).
** Mean ± S.E. of 3 sheep.
# Number of sheep used.

than those with the fibrous residue-silages of legume plants as described previously.[6,9]

On the nitrogen balance, most of all sheep fed silages showed negative nitrogen retention, and this would be due to an increase in nitrogen excretion into urine after feeding silages as indicated in previous paper.[9] In silage feeding, the sheep were forcedly given a large amount of water with feed, because the silage was a high-moisture silage (about 90%). The urine volume, therefore, was markedly increased after feeding of silage. This might has been a cause of the high urinary nitrogen-excretion in silage feeding because the urinary excretion of nitrogen had been reduced by restricting water intake in study of Utley et al.[11] and in our previous study.[9,12] The increase of urinary nitrogen excretion in silage feeding was described by many workers.[13,14] In feeding of silage A, total nitrogen intake was quite lower than that in the feedings of silages B and C, and this might be due to a low intake of silage A as compared with those in feedings of silages B and C, because the nitrogen content of silage A was almost the same as that of silage C as mentioned above. Therefore, a relatively big negative balance of nitrogen after silage A feeding would be induced by a little lower intake of dietary nitrogen, and also by a relatively high level of nitrogen excretion into urine. As mentioned above, crude protein content in silage A was almost the same as that in silage C, but the digestibility of crude protein and retained nitrogen was clearly lower in the former than in the latter. This finding would be due to a difference in the quality of dietary nitrogen of both silages, although its reason did not clarify yet in the present study. From these results, it will be concluded that the food value of the silages B and C as roughage feed for sheep are slmoast similar or a little superior to timothy hay as a reference, if they are fed with some amount of hay to reduce the water intake from ration, and also the water excretion into urine as described earlier.[15,16]

As shown in Table 2, ruminal pH after feeding silages were slightly lower than that after feeding hay, and were in good agreement with that after feedings of residual silages made from legume plants as described previously.[6,9] The ruminal ammonia levels after feeding silages were fairly higher than that after feeding of hay, and the values with silage feedings were in good agreement with those reported earlier using the treated silages made from fibrous residue of legumes.[6,9] In the feeding of the untreated silage of ladino clover-residue, ruminal ammonia level was raised to about 26 mg/100 ml of rumen liquor, and also in feeding of fresh forage it was raised to about 23 mg/100 ml of rumen liquor. The concentrations of VFAs after feeding of silages were slightly higher than that after feeding of hay, and were very comparable to that after feeding of silages made from the fibrous residue of ladino clover,[6] but a little lower than those after feeding of silage made from the fibrous residue of broad bean and fresh forages as reported previously.[9,12]

The Table 3 shows the haematocrit value and the concentrations of blood glucose, blood urea-nitrogen and plasma total protein in sheep fed the silages and hay. Haematocrit values were in a range of normal level in sheep fed roughage diet alone accepted generally.[17] Blood glucose level after feeding silage C was a little lower than those after feedings of silages A and B or hay as a control diet. Blood glucose concentration after feedings of silage made from the fibrous residues

Table 3. The haematocrit value and the concentrations of blood glucose, blood urea-nitrogen and plasma total protein in sheep fed silage diets

Diet	Silage A (3)#	Silage B (3)	Silage C (3)	Hay* (3)
Ht	27.9±5.4**	25.0±3.3	−	24.0
Blood glucose (mg/100 ml)	61.7±7.4	53.8±5.8	44.7±2.5	49.3
Blood urea-nitrogen (mg/100 ml)	10.9±1.0	10.9±1.1	10.1±0.8	11.7
Plasma total protein (g/100 ml)	5.6±0.2	5.9±0.4	7.1±0.7	6.3

* Timothy hay as a reference (see Fujihara & Ohshima, 1982).
** Mean ± S.E. of 3 sheep.
# Number of sheep used.

of ladino clover and broad bean was 41.5−50.3 mg/100 ml of plasma in sheep in our previous experiments.[6,8,9] In general, blood glucose level is thought to be in a range of 50−80 mg/100 ml of plasma in sheep.[18] The level of blood glucose in the feeding of silage A in the present study is a little higher than those in the feedings of silages B and C, but it was still in a range accepted generally as described above.[18] The plasma total protein level was slightly higher after feeding of the silage C than those after feedings of silages A and B. The figures with silages A and B were in good agreement with that with the untreated silage made from the fibrous residue of ladino clover,[6,8] but slightly lower than that with the treated silages made from the fibrous residues of broad bean and ladino clover.[6,9] According to Munro,[19] the plasma protein might represent a vehicle of limited capacity for amino acid transport between the liver and other tissues. The relationships between plasma protein level and plasma free amino acid in sheep should be studied in detail. The difference in plasma protein level after feedings of the 3 silages in this study would be due to some differences in the condition of plasma free amino acids after the feeding of each silage.

Water balance in sheep fed silages and hay is shown in Table 4. Water intake was greater in silage feeding than in feeding hay, and subsequently, urinary water excretion was extremely high in silage feeding. On the other hand, faecal water

Table 4. Water balance in sheep fed on silage diets (g/kg B.W.$^{0.75}$/day)

Diet	Silage A (3)#	Silage B (3)	Silage C (3)	Hay* (3)
Intake				
Feed	256.0±18.1**	342.0± 9.0	288.3±19.2	6.4
Drink	56.7±66.0	0	0	156.6
Total	312.7±81.6	342.0± 9.0	288.3±19.2	161.9
Excretion				
Faecal	26.7± 6.4	20.6± 4.4	36.8± 4.3	40.6
Urinary	251.8±30.0	276.3±12.6	230.0±15.8	71.1
Total	278.5±23.7	296.9± 9.2	266.9±11.5	111.7

* Timothy hay as a referenc (see Fujihara & Ohshima, 1982).
** Mean ± S.E. of 3 sheep.
# Number of sheep used.

excretion tended to be small in feeding of silage. This high water excretion into urine should resulted in a relatively high nitrogen losses into urine as mentioned above. The total intake and excretion of water during experiment (g/kg B.W.$^{0.75}$) was fairly high in the present study than in our previous study using the silage made from the fibrous residue of broad bean.[9] This clearly due to the difference in moisture contents of silages used in both studies. As a whole, the condition of water balance was in agreement with that in the feeding of silages made from the fibrous residue of broad bean as described earlier.[9]

From the results obtained in the present experiment, it would be concluded that the corn silages used here can be utilized in sheep as a roughage feed as same as the silages made from the fibrous residues of legume plants. Furthermore, it is also suggested that the utilization of dietary nitrogen might be improved by using hay jointly to decrease water intake, and then also to decrease urinary water excretion.

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