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THE NITROGEN UTILIZATION IN SHEEP RECEIVING FORAGE DIET IN THE FRESH FORM*

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生草給与時のメンヨウにおける窒素の利用について

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INTRODUCTION

The nutritive value of forage may be decreased with a progress of growth stage in plant, and this would be due to an increase of cellulose in plant and the decrease of dry matter digestibility with plant mature[1]. Similarly, as the plant ages the percent of protein decreases considerably. Ishiguri[2] also reported with orchardgrass hay prepared from a same pasture that the feeding value of 1st cutting hay was lower than that of 2nd cutting one.

The utilization of dietary nitrogen in ruminant receiving the forage diets in fresh form should be influenced by many factors[3,4]. The solubility of forage protein may be an important factor in the rate of its breakdown in the rumen, which could be closely related to the utilization of dietary protein in ruminants[5]. It is also reported that the dietary nitrogen is more utilized efficiently in fresh grass feeding than in hay feeding[6]. The chemical composition of forage may be also an another important factor; that is, the crude protein (as % dry matter) may range from only 3% in very mature forage to over 30% in young leafy grass[7]. Therefore, this should greatly influence the level of nitrogen intake in animal, especially when they were given a similar amount of forage diet. In the experiment, the nitrogen utilization in sheep was investigated when they were received the fresh forage being different in the contents of crude protein and crude fibre. A part of the results in this study was reported previously[8].

EXPERIMENTAL PROCEDURE

Animals and experimental diets

Three Japanese Corriedale male sheep and four wethers, weighing 22–32 kg, were used repeatedly. These sheep were allocated for the three feeding treatments as described previously[8]. The herbage was harvested at three times from the same Italian ryegrass/red clover pasture (1st, 2nd and 3rd cuttings; forages A, B and C). The chemical composition of forage diet was as described earlier[8].

Experimental procedure

The experimental period and feeding management of animal during experiment were

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as described previously[8]. During the 5-day sampling period faeces and urine were collected just before the morning feed. Faeces were dried for 48 hours in forced air drier at 55℃. Urine was collected daily in plastic bottle added a few drops of 10% sulfuric acid to prevent a loss of nitrogen. On the final day of each trial, about 100 ml of rumen contents was sampled using a stomach tube at 9 : 00, 10 : 00, 11 : 00, 12 : 00, 14 : 00 and 16 : 00 hours, and the pH value and the concentrations of ammonia and VFAs of rumen fluid were measured. Similarly, about 5 ml of jugular blood was collected at 9 : 00, 12 : 00, 14 : 00 and 16 : 00 hours on the final day of each trial, and urea nitrogen and plasma total protein were determined.

Chemical analysis

Nitrogen in the diet, faeces and urine were analyzed by the Kjeldahl method, and the contents of crude fat, crude fibre and crude ash in the diet and faeces were determined according to AOAC method[9]. Ammonia in the rumen fluid was analyzed by the method of Oser[10]. Ruminal VFAs were determined by the aeration method[11]. Blood urea-nitrogen and plasma total protein were measured using the Unitest System (Model 300, Biodynamics, Inc., USA).

RESULTS and DISCUSSION

Table 1 shows the apparent digestibility and nitrogen balance in sheep receiving the three diets of fresh forage. The digestibility of organic matter was slightly lower after feeding of forage C than those after feedings of forages A and B. The values after feedings of forages A and B were good in agreement with that reported earlier[6], in which the sheep were given the 2nd-cut Italian ryegrass/red clover in the fresh form at similar level of feeding. The crude protein digestibility after feeding of forage B was fairly higher than those after feedings of forages A and C, and was very comparable with the result of Harumoto and Kato[12], in which the sheep were fed a fresh forage at about 1.2%

Table 1. Apparent digestibility and nitrogen balance

Diet	Forage A (2)*	Forage B (5)	Forage C (3)
Apparent digestibility	(%)		
Organic matter	63.0±1.1**	61.1±1.9	57.1±0.5
Crude protein	61.7±0.5	72.2±2.8	58.1±0.2
Crude fat	61.2±1.5	63.1±1.6	53.8±1.7
Crude fibre	64.7±1.9	47.8±4.6	37.4±0.5
N FE***	62.2±0.7	65.0±0.6	56.9±1.2
Nitrogen balance (g/Kg B.W	$^{0.75}$/day)		
Intake	0.67±0.09	1.57±0.01	1.47±0.06
Fecal	0.26±0.04	0.44±0.04	0.62±0.03
Urinary	0.51±0.02	0.87±0.09	0.73±0.02
Retention	−0.09±0.04	0.26±0.11	0.16±0.04
	(−23.4±12.8)#	(22. 1±9.3)	(10.6±2.4)

* Number of sheep used.
** Mean ± S. E. of 2-5 sheep.
*** Nitrogen freee extract.
# Percent of digested nitrogen (retained N/digested N).

of dry matter per kg body weight (76%). The values after feedings of forage A and C were slightly lower than that of previous work[6]. Ulyatt and Egan[4] reported that the digestibility of nitrogen in fresh forage was 82-86% in sheep when they were hourly given the diet of ryegrasses or white clover in the fresh form. The digestibility of crude fat after feeding of forage C was fairly lower than those after feedings of forages A and B, and this would be due to an increase of clover in the diet of forage as described previously[6]. According to Harumoto and Kato[13], the digestibility of crude fat of fresh clover was about 10% lower than that of fresh Italian ryegrass in sheep. Crude fibre digestibility after feeding of forages B and C were extremely lower than that after feeding of forage A. This would be also due to predominat in number of clover in pasture as mentioned ealier[6]. It is also obvious that the fibre of clover may be lesser digested than that of ryegrass in the fresh form[13]. Digestibility of NFE after feeding of forage C was slightly lower than those after feedings of forages A and B. The values in feedings of forages A and B were similar to that reported earlier[6], but were fairly lower than that of Harumoto and Kato[12], in which sheep were given only fresh grass diet at 1.2-1.4% level per body weight per day. The discrepancy of the results obtained in this study and other experiment might be due to the difference in level of feed intake. Harumoto and Kato[13] also observed that the NFE digestibility was 70.2% in sheep when they were given the fresh clover diet at about 2.0% level per body weight per day.

As indicated in Table 1, faecal nitrogen output was fairly smaller after feeding of forage A than those after feeding of forages B and C, and this might be due to high level of nitrogen intake in feedings of forages B and C. The value after feeding of forage B was lower than that after feeding of forage C, though nitrogen intake was slightly more in former than in the latter. Urinary nitrogen excretion after feeding of forage A was also fairly lower than those after feedings of forages B and C. The value in forage A feeding was fairly low compared with that after timothy hay feeding[14], though the nitrogen intake was similar in both experiments. The values in feedings of forages B and C were slightly higher than that reported previously using fresh Italian ryegrass[6]. As a whole, nitrogen balance was negative after feeding of forage A, and this would be due to low level of nitrogen intake. The retained nitrogen in feedings of forages B and C were slightly lower than that of previous work with fresh Italian ryegrass[6], though the nitrogen intake was almost similar in both experiments. The low utilizability of feed nitrogen after feeding of forage C was might be due to the low digestibility of nitrogen in forage C.

Table 2 shows the ruminal pH and the concentrations of ammonia and VFAs in the ruminal fluid of sheep after feedings of fresh forage diets. Ruminal pH after forage A feed-

Table 2. Ruminal pH and the concentrations of ammonia and VFAs in ruminal fluid of sheep fed only forage in fresh form

Diet	Forage A (2)*	Forage B (5)	Forage C (3)
pH	6.91±0.05**	7.14±0.15	7.20±0.01
Ammonia(mg/100 ml)	11.45±2.44	22.78±2.54	13.83±2.60
VFAs(mM/100 ml)	—	8.11±0.08	7.11±0.95

* Number of sheep used
** Mean ± S. E. of 2-5 sheep.

ing was slightly lower than those after feedings of forages B and C, and these values were slightly high as compared with that reported earlier[6]. The concentration of ruminal ammonia after feeding of forage B was markedly higher than those after feedings of forages A and C, and was in good agreement with that of previous work[6]. The values after feedings of forages A and C were rather similar to that reported earlier[6], in which sheep were given hay diet. The concentration of VFAs after feeding of forage A was not determined. The level of VFAs after feeding of forage B was very comparable to that of Shibata et al[15]. using goats grazed on a predominantly white clover pasture. The VFAs level after feeding of forage C was slightly low as compared with that after feeding of forage B, and this would reflect a low digestibilities of crude fibre and/or nitrogen free extract as shown in Table 1.

Table 3. The concentrations of blood urea-nitrogen and plasma total protein in sheep fed only forage diet in fresh form

	Forage A (2)*	Forage B (5)	Forage C (3)
Ht	26.9±0.6**	26.3±2.0	22.9±2.0
Blood urea-nitrogen (mg/100 ml)	12.59±2.02	16.04±0.25	22.77±1.18
Plasma total protein (g/100 ml)	6.43±0.23	6.08±0.18	5.68±0.04

* Number of sheep used.
** Mean±S. E. of 2-5 sheep.

Table 3 shows the concentration of blood urea-nitrogen and plasma total protein in sheep receiving the fresh forage diets. Haematocrit value was slightly lower after feeding of forage C than after feedings of forages A and B. The values after feedings of forages A and B were slightly lower than that after feeding of fresh forage[6], and were very comparable to those after feedings of various hays[6,14] in our previous works. The concentration of blood urea-nitrogen after feeding of forage C was fairly higher than those after feedings of forages A and B, and was very comparable to that reported earlier[6], in which sheep were given fresh forage or the untreated fibrous residue-silages of ladino clover[17,18]. The figures after feedings of forages A and B were rather similar to that in previous works using sheep given hay[6] and hay with casein[16]. It is obvious that high level of blood urea-nitrogen would be closely related to an increase of ammonia absorption in the rumen[18,19]. The blood urea-nitrogen level after feeding of forage C was fairly higher than that of forage B feeding, though the ruminal ammonia level was high after feeding of forage B than after feeding of forage C. The reason why high level of blood urea-nitrogen and relatively low level of ruminal ammonia occurred after feeding of forage C is not clear at present. A possible reason for this phenomenon may be a high solubility of nitrogen in forage C (large amount of clover), and consequently, ammonia produced in the rumen may be more rapidly absorbed from the rumen wall than when sheep were given forage B diet. This would result in the higher ratio of urinary nitrogen excretion to absorbed nitrogen in forage C feeding (86%) than in forage B feeding (77%). The level of plasma total protein was highest after forage A feeding and was lowest after forage C feeding. The values in the present study were lower than that of previous work[6] and were rather in agreement with those when sheep were given hay diets (5.7-6.3 g/100 ml)[6,17,21]. In our previous work[16], plasma total protein was 6.8-7.1 g

/100 ml in sheep when they were given hay diet and supplemented casein at various levels, although the nitrogen balance was negative in some sheep. In this study, nitrogen balance was negative after feeding of forage A, though plasma total protein level was high. Concerning these facts, it should be necessary to investigate in detail the changes in plasma protein level and the nitrogen balance in sheep when they were given only roughage diets.

From the results obtained in this study, it is obviously shown that nitrogen utilization in sheep was fairly changed with a change in quality of dietary nitrogen as well as a change in dietary amount of nitrogen, even when they were fed the fresh forage diet at similar level of intake.

SUMMARY

In this study, the nitrogen utilization in sheep was investigated when they were given only the fresh forage diet being different in the contents of crude protein (10.6-21.4%) and crude fibre (20.0-30.3%). The fresh forage was harvested at three times (1st, 2nd and 3rd cutting; forages A, B and C) from the same Italian ryegrass/red clover pasture. The ratio of clover in pasture plants tended to increase with a progress of cutting time (1st to 3rd).

The digestibility of organic matter was nearly the same after feedings of three forages used, though there were some variations in the level of food intake in sheep. The digestibility of crude protein was highest after forage B feeding (72%), and was lowest after forage C feeding (58%). The digestibility of crude fibre was extremely low after feeding of forage C as compared with those after feedings of forages A and B. The nitrogen balance was negative after feeding of forage A, whereas a positive nitrogen balance was observed after feedings of forages B and C. The utilizability of dietary nitrogen (retained nitrogen/digested nitrogen) was 22.1 and 10.6% after feedings of forages B and C, respectively.

The changes of chemical values in rumen fluid and blood suggested that it should be necessary to investigate in detail the relationships between the plasma protein level and the nitrogen balance in sheep receiving only roughage diets.

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摘　　要

生草給与時のメンヨウにおける窒素の利用について*

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生草給与時のメンヨウにおける窒素の利用について検討するため，混播草地（イタリアンライグラスと赤クローバ）から刈取った，1，2および3番刈の生草を各々乾物で1日1頭当り体重の1.8〜2.4%の量をメンヨウに給与して代謝試験を行い，次の様な結果を得た．

1．有機物の消化率は1，2および3番刈草給与時でほとんど差はなかった．粗蛋白質の消化率は2番刈草で高い値となり，1および3番刈草ではほぼ同様であった．粗繊維の消化率は1番刈草給与時に比して2および3番刈草給与時では著しく低い値となった．

2．窒素出納では1番刈草給与時で摂取量がかなり少くなり負の値になったが，2および3番刈草給与時では代謝体重 kg 当りの体内蓄積窒素量は0.26および 0.16g/日となり，これらは消化された窒素量の各々22.1および10.6%に相当した．

3．給餌後の第1胃内汁液中のアンモニア濃度は2番刈草給与時では1および3番刈草給与時よりかなり高くなり，低級脂肪酸濃度も2番刈草給与時で高い値となった．一方，血中尿素態窒素濃度は3番刈草給与時で最も高くなり，第1胃壁からのアンモニアの吸収量が多かったものと推測された．この事は3番刈草ではクローバの混入割合が増加したため第1胃内での窒素の分解が速くなったことを示すものであろう．血中総蛋白濃度は必ずしも窒素出納の結果あるいは血中尿素態窒素濃度の変化と一致せず，粗飼料給与時のメンヨウにおける窒素代謝を検討する際の重要な要因であることが示唆された．

*(メンヨウにおける粗飼料の利用性に関する研究，5)