# ルーメン内分解性の異なる補助飼料の給与がサイレージを摂取した山羊の窒素利用性に及ぼす影響


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# Nitrogen Utilization of Goats Fed Silage with or without Supplements Having Different Rumen Degradability

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## Synopsis

**NISHINO, N., N. OKAMOTO and S. UCHIDA (1995) : Nitrogen utilization of goats fed silage with or without supplements having different rumen degradability. *Grassland Science* 41, 202-206.**

**Effects of feeding corn, barley and sugar beet pulp to silage based diet on the nitrogen (N) utilization of goats were studied. These supplements were selected due to having the difference in rumen degradation. Four rumen cannulated goats were fed the diets consisting of wilted ryegrass (*Lolium multiflorum* Lam) silage and the supplements (4 : 1 on dry matter (DM) basis). Silage was solely used for the control diet and N intake was adjusted by urea added to the diets including supplements.**

**The wilted silage showed the pH value 4.72 and relatively high $NH_3$-N concentration (16.7%/total-N). The soluble fraction of DM in the rumen was 58.0, 26.8 and −1.25%, and the rate of degradation was 0.042, 0.107 and 0.099$h^{-1}$, for corn, barley and sugar beet pulp, respectively. Dietary inclusion of corn significantly increased DM and organic matter digestibility, and that of barley increased hemicellulose digestibility compared with the control diet. Urinary excretion of allantoin increased when goats fed the supplements, but the difference failed to be significant. Ruminal concentration of $NH_3$-N and retention of N showed no significant difference among the treatments, but feeding barley tended to lose more N compared with the other supplements in this study.**

**Key words : Goats, Nitrogen utilization, Rumen degradability, Silage, Supplements.**

## Introduction

It is well known that silage nitrogen (N) is inefficiently used compared with fresh herbage or hay[8]. This has been attributed to chemical changes occurred during ensilage. The hydrolysis of protein followed by extensive deamination produces non-protein N and ammonia which would more likely to be excreted compared with protein N, and the conversion of non-structural carbohydrate to organic acids reduces energy yields from the digestion of organic matter in the rumen[1]. These energy and N of silage would be poorly synchronized for microbial synthesis because silage N is rapidly degraded in the rumen[4] and readily digestible carbohydrate has already been fermented during ensilage. The efficiency of microbial synthesis of animals receiving silage based diet could therefore be improved by supplements having substantial amounts of sugars[2,6].

Corn, barley and sugar beet pulp are rich in carbohydrates and commonly used in dairy ration. However, they would differ in the characteristics of rumen degradation, and the effects on N utilization may be different according to the potential of synchronizing energy with the N from silage. The aim of this experiment is to investigate the influence of dietary inclusion of corn, barley and sugar beet pulp on the N utilization of goats given silage based diet.

## Materials and Methods

### Diets

First cut of Italian ryegrass (*Lolium multiflorum* Lam) was harvested at heading stage on 1 June 1993. It was wilted for 5 h and ensiled into vinyl bag silos (1 m in both diameter and height) after chopping into 38 mm length. The herbage was stored for about 5 months until the beginning of animal trial. Corn (rolled), barley (rolled) and sugar beet pulp (pellet) were kindly supplied by Futaba Shiryo Co. Ltd.

### Animal Trial

Four Shiba strain castrated mature goats weighing about 25 kg were used. They were equipped with permanent rumen cannulae and kept individually in metabolism crates. Diet was formulated with ryegrass silage and the supplements at 4 : 1 on dry matter (DM) basis. Silage was solely used for the control diet and N intake was adjusted by urea added to the diets including supplements. Those ingredients were completely mixed at the time of feeding, but goats preferred the supplements rather than ryegrass silage. Daily feed DM was 50 g/kg body weight $(BW)^{0.75}$ and provided at 08 : 00 and 20 : 00 h in two equal meals. Each meal was finished within 1 h.

Water and salt licks were freely accessible at all times. The experiment was designed in a 4×4 Latin-square and each period had 15 days duration. The first 7 days were allocated for diet adaptation and following 5 days for fecal and urinary collection. On day 13, rumen fluid was sampled just before (0h) and at 1, 3, 6, 9 and 12 h after morning meal. Nylon bag incubation was conducted on day 14 through 15, and the disappearance of DM after 3, 6, 9, 12, 24 and 48 h was determined. The dimension of the bag was 10 ×6 cm with a pore size of 42 $\mu$m, and each bag contained 3 g sample which was ground through 2 mm screen. The bags removed from the rumen were washed and dehydrated using a domestic washing machine. Dry matter content of the residue was determined by oven drying at 60℃ for 24 h.

**Analyses**

Chemical compositions of feeds and feces were determined by the methods described previously[10]. Fermentation quality of silage was evaluated on the cold water extracts[9]. Allantoin in urine was quantified according to the method of CHRISTMAN *et al.*[3]. Ruminal concentration of $NH_3$-N was colorimetrically determined[14]. Degradation characteristics of DM was estimated according to the exponential equation $P=a+b(1-e^{-ct})$[11] using non-linear regression analysis procedure of SAS[15]. Data were subjected to analysis of variance and statistical significance was detected by DUNCAN's multiple range test.

## Results

The silage showed the pH value 4.72 and the contents of lactic, acetic, propionic, *iso*-butyric and *n*-butyric acid were 5.02, 1.10, 0.10, 0.03 and 1.99% DM, respectively. Although lactic acid dominated the organic acids, the proportion of $NH_3$-N to total-N was 16.7%.

Crude protein content of silage was 15.1%, which was much more than those of supplements (Table 1). The adjustment of N intake was aimed to see whether the supplement has an advantage as energy over the silage. Urea was chosen in this experiment because it would be as easily degraded as silage N in the rumen. Corn had the highest total non-structural carbohydrate content and beet pulp was rich in fibrous components.

The degradability of DM and parameters describing the degradation characteristics in the rumen were shown in Fig. 1 and Table 2, respectively. Barley had the highest solubility and about 70% of the DM disappeared within the initial 3 h incubation. The soluble fraction of corn was about 27% and the rate of degradation was significantly lower than any other supplements. The solubility of beet pulp was nearly zero but the rate of degradation was similar to that of barley. Although the characteristics of rumen degradation were considerably different,

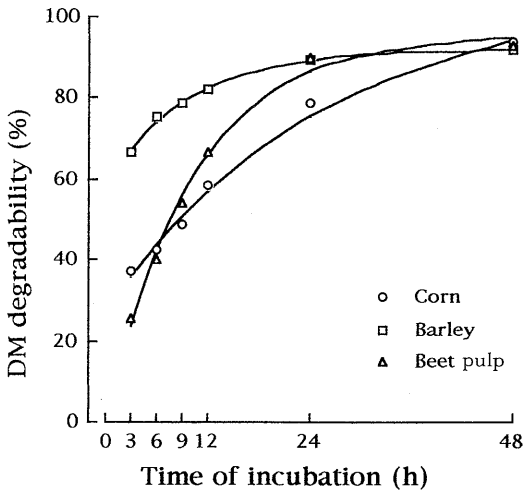


Fig. 1. Dry matter degradability of corn, barley and sugar beet pulp in the incubation course of nylon bags in the rumen.

Table 1. Chemical composition of ryegrass silage, corn, barley and sugar beet pulp used in digestion trial.

| Item | Silage | Corn | Barley | Beet pulp |
|---|---|---|---|---|
| Dry matter (%) | 29.7 | 87.4 | 86.7 | 90.6 |
| Organic matter (% DM) | 87.9 | 98.3 | 97.9 | 91.0 |
| Crude protein (% DM) | 15.1 | 8.63 | 10.1 | 10.6 |
| Ether extract (% DM) | 5.40 | 3.61 | 2.31 | 0.24 |
| NDF (% DM) | 45.3 | 13.1 | 23.0 | 43.1 |
| ADF (% DM) | 30.5 | 4.95 | 7.59 | 26.1 |
| Hemicellulose (% DM) | 14.8 | 8.15 | 15.4 | 17.0 |
| Cellulose (% DM) | 26.7 | 2.61 | 5.82 | 23.8 |
| Lignin (% DM) | 3.77 | 2.34 | 1.77 | 2.34 |
| TNC (% DM) | 22.1 | 73.0 | 62.5 | 37.1 |

Mean values of 4 samples. TNC, Total non-structural carbohydrates=100−(Crude protein+Ether extract+NDF+Crude ash).

about 90% of DM disappeared at 48 h incubation in all the supplements.

When diet included the supplements, digestibility of dry matter and organic matter increased, although significant difference was found only when goats fed corn (Table 3). The digestibility of other nutrients was not affected by the supplements except that of hemicellulose, which significantly increased when goats fed barley compared with control diet.

The goats given barley excreted more N in urine than those given beet pulp, although the difference with goats on control diet was not significant (Table 4). Retention of N was not greatly affected by the supplements. Urinary excretion of allantoin, determined as an indicator of microbial biomass production in the rumen, tended to increase by dietary inclusion of the supplements, although the difference failed to reach significant.

Changes in ruminal $NH_3$-N concentration were not much influenced by diet (Fig. 2). The concentration of goats given control diet peaked at 3 h after feeding, but those of goats given the supplements peaked at 1 h after feeding. When goats fed barley, they showed significantly higher $NH_3$-N concentration than goats on the other diets just before the morning meal.

## Discussion

Table 2. Degradation characteristics of dry matter of corn, barley and sugar beet pulp according to the exponential equation $P=a+b\,(1-e^{-ct})$.

| | Corn | Barley | Beet pulp | SE |
|---|---|---|---|---|
| Soluble fraction (%) | $26.8^{b}$ | $58.0^{a}$ | $-1.25^{c}$ | 1.83 |
| Degradable fraction (%) | $78.8^{b}$ | $33.9^{c}$ | $96.9^{a}$ | 2.26 |
| Rate of degradation ($h^{-1}$) | $0.042^{b}$ | $0.107^{a}$ | $0.099^{a}$ | 0.004 |

Means of 4 goats. Values within the same row having different superscript letters are significantly different ($P<0.05$).

Table 3. Digestibility of nutrients by goats given ryegrass silage with or without corn, barley and sugar beet pulp.

| Item | Diet including supplement of | | | | SE |
|---|---|---|---|---|---|
| | None | Corn | Barley | Beet pulp | |
| | (%) | | | | |
| Dry matter | $67.9^{b}$ | $73.0^{a}$ | $71.6^{ab}$ | $70.0^{ab}$ | 1.26 |
| Organic matter | $64.5^{b}$ | $70.6^{a}$ | $69.5^{ab}$ | $67.5^{ab}$ | 1.65 |
| Crude protein | 75.4 | 76.5 | 76.8 | 74.0 | 1.03 |
| NDF | 55.0 | 57.7 | 59.5 | 59.5 | 2.12 |
| ADF | 59.9 | 61.0 | 56.6 | 63.1 | 2.30 |
| Hemicellulose | $44.7^{b}$ | $51.2^{ab}$ | $54.4^{a}$ | $52.8^{ab}$ | 2.91 |
| Cellulose | 68.3 | 68.5 | 67.0 | 71.0 | 1.88 |

Means of 4 goats. Values within the same row having different superscript letters are significantly different ($P<0.05$). Nitrogen intake was adjusted by urea added to the diets including supplements.

Table 4. Nitrogen balance and urinary excretion of allantoin in goats given ryegrass silage with or without corn, barley and sugar beet pulp.

| Item | Diet including supplement of | | | | SE |
|---|---|---|---|---|---|
| | None | Corn | Barley | Beet pulp | |
| Intake N ($g/kg^{0.75}$/day) | 1.21 | 1.21 | 1.21 | 1.21 | 0.01 |
| Fecal N ($g/kg^{0.75}$/day) | 0.30 | 0.29 | 0.28 | 0.32 | 0.02 |
| Urinary N ($g/kg^{0.75}$/day) | $0.67^{ab}$ | $0.67^{ab}$ | $0.73^{a}$ | $0.62^{b}$ | 0.02 |
| Retained N ($g/kg^{0.75}$/day) | 0.24 | 0.25 | 0.20 | 0.27 | 0.03 |
| Allantoin ($mg/kg^{0.75}$/day) | 64.5 | 76.9 | 75.2 | 70.4 | 5.75 |

Means of 4 goats. Values within the same row having different superscript letters are significantly different ($P<0.05$). Nitrogen intake was adjusted by urea added to the diets including supplements.

Of the three supplements used in this study, corn had the highest total non-structural carbohydrate content. However, the soluble fraction and rate of degradation of DM were below the half of those of barley. These facts indicated that an energy release from corn was relatively mild while from barley most of the energy would be provided during an early digestion period. The difference between corn and barley may be ascribed to starch degradation, because the main component of the two supplements would be disappeared differently in the rumen[13]. Nearly all the DM of beet pulp was classified as degradable fraction, but the rate constant was high enough to show its potential as a highly digestible energy source.

Since a large proportion of silage N would be easily solubilized in the rumen, the animals receiving silage-based diet may exhibit a rapid increase of $NH_3$-N concentration as found in Fig. 2. These N supply in excess of microbial needs and an shortage of fermentable carbohydrate would result in substantial N loss in the rumen. Therefore, the energy supplement showing a high degradability at an early digestion period had seemed to be effective for enhancing N incorporation by microbes. When barley was included in the diet, however, goats lost the most N in urine. The disappearance of protein in the rumen was not determined in this experiment, but barley protein may be rapidly degraded compared with corn and beet pulp protein as supposed by the disappearance of DM. Thus, the amount of protein escaped from degradation in the rumen would decrease when goats fed barley. The efficiency of microbial protein production from rumen degradable protein may also decrease even if the quantity of synthesis increased.

The high concentration of ruminal $NH_3$-N just before the morning meal might indicate the energy from barley had been consumed before the following meal was supplied. In contrast, a chronic energy deficiency might be compensated when goats fed corn and beet pulp which were degraded slowly and continuously in the rumen. Sucrose supplement for cattle given silage-based diet was reported to have greater effects on microbial N production when administered continuously into the rumen compared with those ingested twice a day[6].

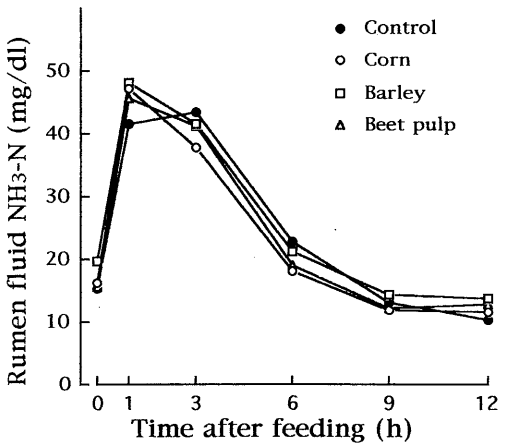


Fig. 2. Rumen fluid $NH_3$-N concentrations of goats given ryegrass silage with or without corn, barley and sugar beet pulp.

In this experiment, feeding supplements with silage-based diet did not show either a significant increase of urinary allantoin or a reduction of peak concentration of ruminal $NH_3$-N after feeding. These results may be due to the low proportion (20%) of supplements and the addition of urea in the diet. When more supplements was included in silage-based diets, the efficiency of microbial N synthesis could be improved[5,12]. Although urea and silage N would be similarly susceptible to degradation, urea may be less efficient for microbial production in the rumen, because the synthesis is known to be stimulated by the supply of amino acids rather than urea[7]. This study suggested that although barley had high content of non-structural carbohydrates, it seemed to be less effective than corn and sugar beet pulp for enhancing N utilization of animals on silage-based diet.

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## 要　　旨

西岡直樹・岡本信重・内田仙二（1995）：ルーメン内分解性の異なる補助飼料の給与がサイレージを摂取した山羊の窒素利用性に及ぼす影響．*Grassland Science* **41**, 202-206．岡山大学農学部（700 岡山市津島中 1-1-1）

とうもろこし，大麦およびビートパルプというルーメン内分解性の異なる補助飼料の給与が，サイレージを摂取した山羊の窒素利用性に及ぼす影響について検討した。イタリアンライグラスより調製した予乾サイレージと各補助飼料を 4 : 1 （乾物比） の割合で混合し，ルーメンフィステルを装着した山羊 4 頭に給与して消化試験を実施した。対照区にはサイレージのみを給与し，補助飼料給与区には尿素を与えて窒素摂取水準を等しくした。

予乾サイレージの pH は 4.72 であり，$NH_3$-N （% total-N） は 16.7% と高い値であった。ルーメン内における乾物の可溶性区分割合は，とうもろこし，大麦およびビートパルプがそれぞれ 58.0, 26.8 および −1.25% であり，分解性区分の分解速度はそれぞれ 0.042, 0.107 および 0.099$h^{-1}$ であった。対照飼料に比べ，とうもろこしを給与すると乾物および有機物の消化率が，また大麦を給与するとヘミセルロースの消化率が有意に高くなった。尿中のアラントイン排泄量は補助飼料の給与により増加したが，有意差は認められなかった。飼料給与後のルーメン内 $NH_3$-N 濃度および保留窒素量も給与飼料による有意な違いが認められなかったが，本実験では，大麦を給与すると窒素の損失量が多い傾向にあった。

キーワード：サイレージ，窒素利用性，補助飼料，山羊，ルーメン内分解性．