NUTRITIONAL QUALITY OF WILTED NAPIER GRASS (*Pennisetum purpureum* Schum.) ENSILED WITH OR WITHOUT MOLASSES

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Summary

To investigate the effects of molasses addition at ensiling on nutritional quality of wilted napier grass, chemical quality and nutrient composition of the silages, digestibility and nitrogen retention at feeding trials were analysed using 4 goats in a cross over design. The results are as follows:

1. Molasses addition at ensiling decreased pH value (3.99) and ammonia nitrogen, and increased lactic acid content by 285% compared to non-additive silage (83.5 g/kg dry matter).
2. There were no differences in digestibilities of dry matter, crude protein, neutral detergent fiber, acid detergent fiber, hemicellulose and cellulose between the silage ensiled with molasses (MS silage) and the silage ensiled without molasses (WS silage). Urinary nitrogen excretion, however, significantly ($p < 0.05$) decreased in goats fed the MS silage, and nitrogen retention was positive in goats fed the MS silages, but negative in goats fed the WS silage.
3. Acetic acid concentration in ruminal fluids in goats fed the MS silage was lower and propionic and butyric acid concentrations were higher than those in goats fed the WS silage. As water soluble carbohydrate content was higher in the MS silage than in the WS silage, a part of added molasses was still remained in the silage at the feeding trials and could be utilised for energy sources by the goats. Nitrogen may be also effectively utilised in goats fed the MS silage, because the silage were inhibited in proteolysis during ensiling.

(**Key Words**: Napier Grass, *Pennisetum purpureum*, Silage, Nutritional Quality)

Introduction

Napier grass (*Pennisetum purpureum* Schum.) is well known in wet tropical and subtropical areas for its high-yielding capacity and is a popular feedstuff for ruminants. Even in south-coast of Japan the grass can be harvested 5 times a year and the yields of dry matter and crude protein were 19 and 2.8 ton/ha (Yokota et al., 1991). Crude protein content of the grass, however, decreased with the age of the grass; 24% at 4 weeks, 10% at 12 weeks and 7% at 24 weeks (Gomide et al., 1969). Because hay from napier grass is difficult to make due to thick stems of the grass, it was advisable to preserve the grass as a silage (Woodard et al., 1991). The grass has deficits of high moisture content when it was harvested at young stages. To make a silage with good quality, moisture content should be controlled. Yokota et al. (1991, 1992b) reported that napier grass ensiled with molasses had good quality, and dry matter and nitrogen digestibilities of the silage were 65 and 55%, respectively (Yokota et al., 1992b). A lower moisture silage is easy to feed for ruminants and increased voluntary intake of animals (McDonald et al., 1968, Gordon, 1981, Haigh and Parker, 1985). Yokota et al. (1992a) also reported that the napier grass silage was increased pH value and decreased lactic acid content by being wilted the material before ensiling. Molasses addition to the wilted napier grass at ensiling, however, could prepare a good quality silage.

Objectives of the following study were to investigate chemical and nutritional quality of wilted napier grass ensiled with and without molasses.

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Materials and Methods

1. Preparation of silages

Napier grass (Merkeron) was cultured at The Farm of Nagoya University and harvested on October 17, 1990. The grass was wilted in a glass house for 2 days and cut 0.9 cm in length with a forage cutter. One group of the grass was directly packed (WS silage) in plastic bags (625 mm in width, 800 mm in height and 0.06 mm in thickness). Another group of the grass was well mixed with 4% of molasses (in weight) and packed (MS silage). The weight of the silages was 15 kg each in a bag. After removing air with a vaccum pump the upside of the bag was tied with a string and stored at a dark room at ambient temperature. The silages were opened at 7 months after preparation and fed to the goats for animal trials as follows.

2. Animal trials

Two kinds of silages were given to 4 goats (Shiba strain Japanese pigmy goats, mean body weight 17 kg) by a cross over design. The goat was individually reared in a metabolism cage and fed a diet at 2% of the body weight daily in dry matter basis. A half of the ration was given at 08:30 and another half at 17:30. Water was freely accessed. Mineral blocks were always available to lick in the trough. As the WS silage contained less nitrogen than the MS silage, urea was given to adjust the nitrogen intake. Digestion and nitrogen balance tests were on the collection method of all the feces and urine. One silage was given for 13 days and feces and urine were collected for 5 days from day 8 to day 12. At day 13 blood and ruminal fluid were collected from jugular vein and with stomach tube, respectively at 0 hour (just before the feeding in the morning), 1, 2, 4, 8 hours after the morning feeding. After measuring pH value, ruminal fluid was filtered through a double cheese cloth and added a few drops of mercury chloride to stop further fermentation. Blood plasma was taken by centrifugation of the blood and stored at −15℃ until analysis. Feces were dried at 60℃ for 48 hours and urine was stored at −15℃ until analysis.

3. Analysis

Dry matter of silages were analysed by toluene distillation method (Dewar and McDonald, 1961). Silage quality was estimated on the samples of cold water extraction of silages. The pH values were determined with a glass rod electric pH meter. Lactic acid was analysed photometrically by the method of Barnett (1951). Volatile fatty acids and ammonia nitrogen were determined by steam distillation method and molar ratio of VFA was analysed by gas chromatography (GC-12A, Shimadzu, Kyoto). Water soluble carbohydrate in silages were determined by the anthrone method, which was reported by Yemm and Willis (1954). One gram of freeze dried sample was boiled with 150 ml of distilled water with a cold finger condenser for 2 hours and filtered through Toyo No 2 filter paper. Two ml of 29.5 N of sulfuric acid containing 1 mg of thiourea and 1 mg of anthrone were added into 2 ml of filtrates, and the mixed solution was boiled again for 20 minutes. The solution was photometrically measured at 625 nm against glucose standard solution.

Composition of silages were analysed with freeze-dried samples. Nitrogen was determined by Kjeldahl method on fresh silages. Analysis of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were done by the methods of Van Soest and Wine (1967), and Van Soest (1963), respectively. Hemicellulose and cellulose were calculated by (NDF-ADF) and (ADF-acid detergent lignin), respectively.

Gross energy in the silages and feces were analysed with bomb calorimeter (CA-3, Shimadzu, Kyoto). Glucose, total protein and urea nitrogen in blood plasma were determined with commercial kits (Unikit, Chugai, Tokyo).

4. Statistics

Comparision of means was analysed by Students' t test.

Results and Discussion

Chemical quality of silages prepared from the wilted napier grass in the present experiment is shown in table 1. Dry matter of silages prepared without molasses (WS silage) was 25.3%, and silages prepared with 4% of molasses (MS silage) was 27.3%. Addition of molasses decreased pH value of silages to under 4.0, and increased lactic acid content by 285% and decreased total VFA content by 28% compared to the WS silage. The ratio of lactic acid content to total acid content was 92% in the MS silage while it was only 54% in the WS silage. Yokota et al. (1991, 1992b) reported that molasses was necessary for preparing good quality silages which had a higher level of lactic acid and lower levels of pH value and acetic and butyric acids from the unwilted napier grass. Davies (1963), however, reported that wilting was more effective than addition of molasses to prepare good quality silages from tropical grasses. Comparisons of silages in 2 levels of wilting of napier grass showed that a higher value of pH and a ratio of ammonia nitrogen content to total nitrogen content (AN/TN ratio) and a lower content of lactic acid were shown in silages with a higher DM content. However, the quality of silages which DM was less than 20% was almost the same as silages ensiled directly (Yokota et al., 1992a). The present experiment showed that WS silage having 25% DM showed more protein degradation and AN/TN ratio during ensiling than the MS silage. The main preservative acid was acetic acid in silages prepared from tropical grasses (Catchpoole and Henzell 1971, Kim and Uchida 1990, Pandithararatne et al., 1986). In this experiment, however, lactic acid was the main preservative acid. When the silages were prepared from the direct cut of napier grass which was harvested at an interval of about a month (Yokota et al., 1992a), the ratio of lactic acid content to total acid content (LA/TA ratio) was 31% and the main preservative acid was acetic acid. The pH value of these silages was 5.09 and the quality was not good. Molasses addition to those materials, however, increased LA/TA ratio to 61%. They suggested that the difference of the main preservative acid was depend on the content of water soluble carbohydrates in the original grasses. McDonald and Whittenburg (1973) reported that silages with a higher acetic and a lower lactic acid could be prepared in a small size of silo in laboratories. As shown in table 1, WSC content in the MS silage was significantly higher than that in the WS silage. This shows that a part of added molasses was still remained in the MS silage.

Chemical composition of silages prepared in the present experiment are shown in table 2. Crude protein content in the MS silage was higher a little than that in the WS silage, because molasses contains a small amount of crude protein. Contents of NDF, ADF, acid detergent lignin, hemicellulose and cellulose were low in the MS silage ($p < 0.05$), but silica and gross energy were not different.

Results in animal feeding trials are shown in table 3. The DM and fiber digestibilities were higher in the MS silage than in the WS silage,

TABLE 1. CHEMICAL QUALITY OF THE NAPIER GRASS ENSILED WITH OR WITHOUT MOLASSES

	Molasses	
	−	+
Dry matter (%)	25.29 ± 0.67[1]	27.25 ± 0.63*[2]
pH	4.72 ± 0.04	3.99 ± 0.01*
Lactic acid (% DM)	2.93 ± 0.12	8.35 ± 0.52*
Total VFA (% DM)	2.46 ± 0.08	0.68 ± 0.04*
Acetic acid (% DM)	2.42 ± 0.08	0.68 ± 0.04*
Propionic acid (% DM)	0.03 ± 0.01	trace
i-Butyric acid (% DM)	trace	trace
n Butyric acid (% DM)	0.02 ± 0.01	trace
Total acids (% DM)	5.39 ± 0.12	9.03 ± 0.55*
Lactic acid/Total acids (%)	54.26 ± 0.02	92.44 ± 0.01*
NH_3-nitrogen/Total nitrogen (%)	24.99 ± 1.07	12.60 ± 0.65*
Water soluble carbohydrate (% DM)	0.24 ± 0.02	0.90 ± 0.01*

[1] Mean ± SE (n=4).

[2] Asterisks show that the value of the molasses additive silages is significantly different from one of non-additive silage ($p < 0.05$).

TABLE 2. CHEMICAL COMPOSITION OF THE NAPIER GRASS ENSILED WITH OR WITHOUT 4% OF MOLASSES

	Molasses	
	−	+
Dry matter (%)	25.29 ± 0.67[1]	27.25 ± 0.63*[2]
Crude protein (% DM)	8.05 ± 0.21	8.30 ± 0.30
Neutral detergent fiber (% DM)	63.15 ± 0.05	58.26 ± 0.04*
Acid detergent fiber (% DM)	41.55 ± 0.06	38.25 ± 0.03*
Acid detergent lignin (% DM)	5.28 ± 0.10	4.68 ± 0.08*
Silica (% DM)	3.61 ± 0.11	3.34 ± 0.03
Hemicellulose (% DM)	21.61 ± 0.09	20.01 ± 0.06*
Cellulose (% DM)	36.28 ± 0.09	33.58 ± 0.07*
Gross energy (kcal/g DM)	3.84 ± 0.01	3.78 ± 0.02

[1] Mean ± SE (n=4).
[2] Asterisks show that the value of the molasses additive silages is significantly different from one of non-additive silage ($p < 0.05$).

TABLE 3. DIGESTIBILITIES OF SOME NUTRIENTS AND NITROGEN BALANCE OF GOATS FED NAPIER GRASS ENSILED WITH OR WITHOUT MOLASSES

	Molasses	
	−[2]	+
Digestibility (%)		
Dry matter	54.29 ± 1.77[1]	58.07 ± 3.85
Crude protein	66.00 ± 1.69	65.92 ± 3.53
Neutral detergent fiber	54.33 ± 1.70	56.67 ± 3.99
Acid detergent fiber	58.34 ± 1.52	60.56 ± 3.60
Acid detergent lignin	17.10 ± 3.96	20.63 ± 7.06
Hemicellulose	46.92 ± 2.13	49.32 ± 4.74
Cellulose	64.29 ± 1.27	66.23 ± 3.11
Gross energy	55.05 ± 1.12	57.07 ± 4.31
Nitrogen balance (g/day)		
Intake nitrogen	5.31	5.31
Faecal nitrogen	1.81 ± 0.09	1.81 ± 0.19
Urinary nitrogen	3.96 ± 0.14	3.34 ± 0.15*[3]
Retained nitrogen	−0.45 + 0.13	0.16 + 0.30

[1] Mean ± SE (n=4).
[2] Urea was supplemented at feeding time to adjust the nitrogen intake.
[3] Asterisk shows that the value of the molasses additive silage is significantly different from one of non-additive silage ($p < 0.05$).

but not significant. Crude protein digestibility was the same between the two silages. Urinary nitrogen excretion, however, was significantly lower ($p < 0.05$) in the MS silage than in the WS silage. Retained nitrogen of the goats fed the WS silage was negative and that of the goats fed the MS silage was positive.

Total protein, glucose and urea nitrogen concentrations in blood plasma of goats fed the silages are shown in table 4. Although blood was taken 5 times before and after the morning feeding, mean values of each items are shown in the table. Urea nitrogen concentration of the goats fed the MS silage was significantly lower

TABLE 4. MEAN VALUES OF TOTAL PROTEIN, GLUCOSE AND UREA NITROGEN CONCENTRATION IN BLOOD PLASMA OF GOATS FED WILTED NAPIER GRASS ENSILED WITH OR WITHOUT MOLASSES

	Molasses	
	−	+
Total protein (g/100 ml)	6.31 ± 0.12[1]	6.35 ± 0.16
Glucose (mg/100 ml)	61.03 ± 3.25	58.10 ± 0.98
Urea nitrogen (mg/100 ml)	16.55 ± 0.53	14.36 ± 0.74*[2]

[1] Mean ± SE (n=20).

[2] Asterisk shows that value of molasses additive silage is significantly different from one of non-additive silage ($p < 0.05$).

than that of the goats fed the WS silage ($p < 0.05$).

Characteristics of rumen fluids of the goats fed the WS and the MS silages are shown in figure 1. The pH values of the ruminal fluid of goats fed the MS silage decreased at 1 hour after feeding. This phenomenon is supported by Ohshima et al. (1991) that ruminal pH reduced drastically just after feeding of a higher lactic acid containing silage and synchronized with a higher lactic acid content in the ruminal fluid. At 2 hours after feeding pH values reached at maximum and thereafter decreased gradually irrespective of the diets, but the change was very small. Ruminal ammonia nitrogen concentrations were increased by feeding and showed almost the same pattern in the two silages. Ruminal acetic acid concentration increased after the morning feeding and the maximum was shown at 2 hours after the feeding, but there was no difference between the two silages. However, concentrations of propionic and butyric acids were higher in the ruminal fluid of goats fed the MS silage than the WS silage, and significances were shown at 2, 4 and 8 hours of propionic acid and at 2 hours of butyric acid after the feeding. Because propionic acid was produced from lactic acid in the rumen (Russel and Hespell, 1981), high level of propionic acid in the rumen fluid might be derived from the high lactic acid concentration in the MS silage. As shown in table 1, remaining WSC in MS silage might increased propionic acid concentration in ruminal fluid after feeding, because propionic acid is produced from hexoses in WSC. The higher concentration of butyric acid in the ruminal fluid of goats fed MS silage might be explained by the fact that

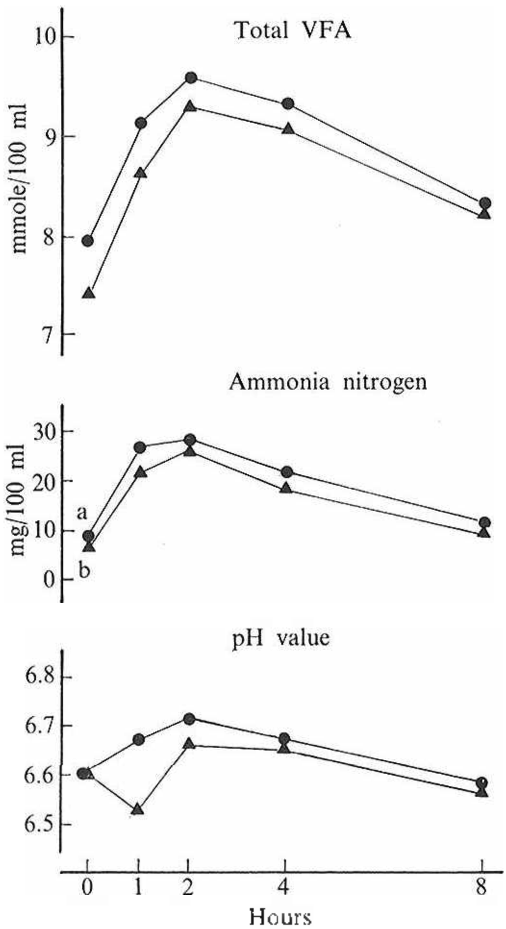

Figure 1. Time course of ruminal pH and ammonia nitrogen and total VFA concentration of goats fed wilted napier grass with (▲) and without (●) molasses. The data show means of 4 goats. Different letters in the same hour are statistically different at 5% level.

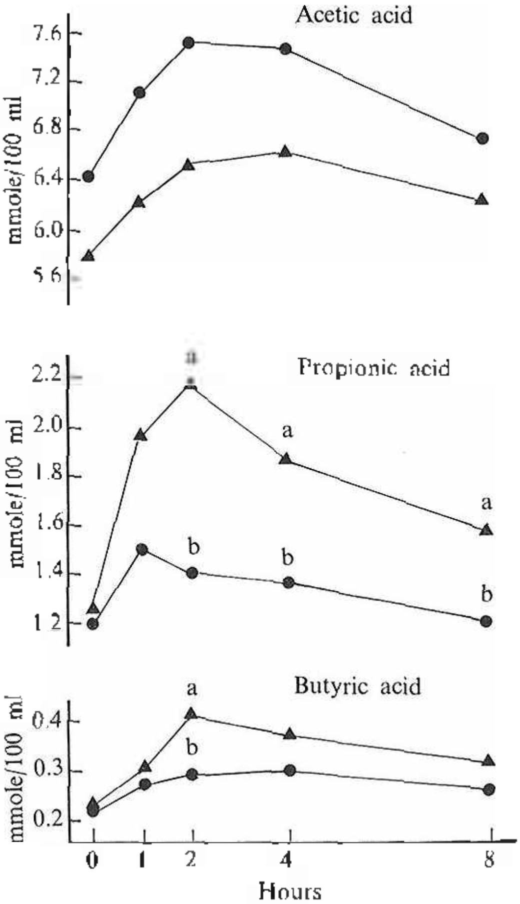

Figure 2. Time course of ruminal acetic, propionic and butyric acid concentration of goats fed wilted napier grass with (▲) and without (●) molasses. The data show means of 4 goats. Different letters in the same hour are statistically different at 5% level.

the acid was produced at ruminal protein degradation, because nitrogen contents and nitrogen digestibilities of the two silages were almost the same. The similar results was reported in the case of hays and silages which were prepared from the same original herbage (Ohshima et al., 1991).

In this experiment, the effect of molasses addition to the wilted napier grass on silage quality, digestibilities of nutrients, ruminal fluid characteristics and blood constituents were examined. The goats fed the wilted silage in which the ammonia nitrogen concentration was high had higher urea nitrogen concentration in blood plasma and urinary nitrogen excretion and decreased the retained nitrogen in animals. It is necessary, therefore, to establish the method for preparing silages of lower ammonia concentration in order to use it for animal production from the tropical grasses

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