EFFECT OF ENVIRONMENTAL TEMPERATURE AND ADDITION OF MOLASSES ON THE QUALITY OF NAPIER GRASS (*PENNISETUM PURPUREUM* SCHUM.) SILAGE

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Summary

The effect of molasses addition and hot temperature on the ensiling characteristics of napier grass (*Pennisetum purpureum* Schum.) were studied. Napier grass was harvested five times at intervals from 22 to 39 days and each harvest was divided into two equal portions. The half portion was ensiled directly and the other half was ensiled after mixing with molasses into polyethylene bag silos of 15 kg capacity. Molasses was added at the rate of 4% of fresh weight of the grass. One half of the each treatment was conserved at a room of 40℃ for a month and then moved to an ambient temperature room. The other half was kept at ambient temperature for the whole experimental duration. The silages were opened 3 to 7 months after ensiling. Addition of molasses enhanced lactic acid fermentation by increasing lactic acid content and reducing pH value, ammonia nitrogen and acetic, propionic and butyric acid contents of the silages in both temperature treatments. Enhanced temperature increased pH value and decreased acetic, propionic and butyric acids.
(Key Words : Napier Grass, *Pennisetum purpureum*, Silage Quality, Molasses)

Introduction

Napier grass (*Pennisetum purpureum* Schum.) is one of the most popular grass in tropical and subtropical areas, and considerable amounts of research has been done to study the effect of frequency of harvests on dry matter production and nutritive value. The utilization of the grass for silage has been also investigated. Generally, tropical forages are low in water soluble carbohydrate (WSC), which is very important for preserving silage. Several workers have shown that the fermentation pathways of tropical grass silages were different from temperate grass silages and they suggested that acetic acid was the main preservative acid rather than lactic acid in tropical grass silages (Catchpoole and Henzell, 1971, Panditharatne et al., 1986, Ibrahim et al., 1989). The objectives of the study were to investigate the effects of high temperature during conservation period of silages and supplementation of molasses as WSC on the quality of napier grass silage.

Materials and Methods

Our research station is located in the middle part of Honshu island (main island of Japan) and the average annual temperature is 14.5℃. Napier grass (Merkeron) was established by planting mature stem cutting at first week of April 1985 and harvested it several times until November 1985. During winter stubbles of napier grass should be mulched to protect from low temperature. Rice hulls were used as mulching material. The grass was harvested 5 times (Jun. 26, Jul. 16, Aug. 20, Spt. 12, and Oct. 21, 1986) and used for the silage preparations. Fertilization (N 150 kg, P_2O_5 50 kg, and K_2O 40 kg/ha) was done on May 10, 1986 and the next days of each harvest. Sward height, dry matter yield and crude protein yield were estimated on each harvest.

Preparation of silages

The grass was chopped (2 cm) and ensiled directly or after mixing well with 4% of molasses on fresh matter basis into polyethylene bags (625 mm in width, 800 mm in height and 0.06

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mm in thickness) at a rate of 15 kg of fresh grass per bag. After removing air with a vacuum pump and tying the opening, half of the bags of each treatment were preserved in a dark room at ambient temperature and another half were preserved in a room of which temperature was controlled at 40℃ for a month and thereafter transferred into the same room as the former group. Conservation periods for silages were for 3 to 7 months, because all silages were opened on mid-January in 1987.

Chemical analysis

Dry matter of the grass was determined by drying it in an oven at 60℃ for 48 hours. Dried grass was ground to pass 1 mm sieve and analysed for dry matter (DM) and crude protein (N × 6.25). Dry matter content of silages were estimated by toluene distillation method (Dewar and McDonald, 1961), which was done randomly only on one bag per treatment. Nitrogen contents of silages and grass samples were determined by Kjeldahl method. Chemical quality of silages was determined with cold water extracts. Twenty grams of well mixed silage sample were put into 200 ml of water and stored at 5℃ for 1 day. The filtrates were used for determining pH value, lactic acid, volatile fatty acids (VFA) and ammonia-N contents. Value for pH was determined with a glass electrode pH meter (Corning pH 107, Iwaki, Tokyo). Lactic acid was determined according to Barnett (1951). Total VFA and ammonia-N concentration were analysed by steam distillation method and molar proportion of VFA was determined by gas chromatography (GC-12A, Shimadzu, Kyoto). All data were subjected to analysis of variance and statistical significance was determined by Duncan's range test. Calculation (SAS, General Linear Models Procedure) was done at Nagoya University Computer Center.

Results

As shown in table 1 napier grass was harvested 5 times a year at intervals of 22 to 39 days in this experiment. Sward length was 92 to 142 cm. The maximum productions in dry matter (DM) and crude protein (CP) (kg/ha/day) were shown at the 2nd harvest, because it was at end of the rainy season and temperature was gradually increased day by day after the 1st harvest. Daily DM yield was gradually decreased after the 2nd harvest, although CP yield was decreased at the 3rd harvest and increased again at the 4th harvest. Annual DM and CP yields were about 19.0 and 2.8 ton/ha, respectively. Annual DM and CP yields of corn and sorghum would be about 30 and 1.8 ton/ha in this area, respectively. Dry matter of silages was increased ($p < .05$) with adding molasses, but it was not affected by the environmental temperatures (tables 2 and 4). Addition of molasses had an effect on decreasing pH value of the silages, but enhancing temperature increased pH value ($p < .001$, tables 2 and 4). Lactic acid concentration in silages with molasses was drastically higher compared with that in silages without molasses ($p < .05$, tables 2 and 4), and there was a tendency of decreasing lactic acid concentration with temperature increased for both silages with and without molasses.

TABLE 1. DATE OF HARVEST OF NAPIER GRASS AND ITS PRODUCTION OF DRY MATTER AND CRUDE PROTEIN

Date	Harvest interval	Weather	Sward length	Dry matter yield		Crude protein yield	
	days		cm	kg/ha	kg/ha/day	kg/ha	kg/ha/day
1986							
Jun. 26		fine	112	2769	–	482	–
Jul. 18	22	fine	142	4082	186	649	29.5
Aug. 20	33	fine	115	5800	176	574	17.4
Sep. 12	23	rain	117	2932	127	625	27.2
Oct. 21	39	fine	92	3382	87	504	12.9
Total				18965		2834	

Ammonia nitrogen to total nitrogen in silages treated with molasses was less than 10%, but it was more than 20% in those ensiled without molasses; the differences were significant ($p < .001$, tables 2 and 4). The temperature treatment had no effects on it. Concentrations of VFA (acetic, propionic, butyric and valeric acids) were significantly ($p < .01$) reduced by adding molasses (tables 3 and 4).

Discussion

The forage crops suitable for silage preparation contain an adequate level of fermentative substrates in the form of water soluble carbohydrate (WSC). Temperate grasses, i.e., Italian ryegrass and perennial ryegrass, which are commonly used for silage contained WSC 181 (ranged from 74 to 314 g/kg) and 170 (ranged from 46 to 315 g/kg) g/kg DM, respectively (McDonald, 1981), while napier grass contained only WSC 54 g/kg DM (Uchida and Kitamura, 1987). In the present experiment silages with molasses showed to increase levels of DM and lactic acid and to decrease levels of pH value, proportion of ammonia to total nitrogen and all VFAs which were analysed. Molasses used in this experiment contained 72% of DM. Molasses contained WSC about 650 g/kg DM (McDonald, 1981). When averaged DM of napier grass used in this experiment was 12% and 4% of molasses was supplemented at fresh grass basis, about 156 g of WSC ($0.65 \times 40 \times 72/100 \times 1/0.12$) per kg DM of the grass was added into silages. Napier grass added with molasses in this experiment would contain WSC

TABLE 2. EFFECTS OF ENVIRONMENTAL TEMPERATURE DURING ENSILING AND ADDING 4% MOLASSES ON DRY MATTER CONTENTS, pH VALUE, LACTIC ACID CONTENT AND AMMONIA-N / TOTAL N OF NAPIER GRASS SILAGE

Treatment		Date of harvest					
Temperature	Molasses	Jun. 26	Jul. 18	Aug. 20	Sep. 12	Oct. 21	Mean
Dry matter contents (%)							
+	−	10.9	10.3	13.6	13.3	−	12.0
−	−	12.3	11.0	14.1	13.3	13.9	12.9
+	+	14.7	12.6	15.5	12.7	−	13.9
−	+	14.7	12.9	16.4	14.2	15.9	14.8
Mean		13.2	11.7	14.9	13.4	14.9	
pH value							
+	−	7.93	4.95	6.66	7.17	−	6.47
−	−	5.69	5.22	4.76	5.18	4.58	5.09
+	+	4.34	4.13	4.25	4.37	−	4.27
−	+	4.41	3.81	3.93	3.75	3.84	3.95
Mean		5.46	4.53	4.90	5.12	4.12	
Lactic acid content (g/kg DM)							
+	−	8	13	2	0	−	6
−	−	7	2	3	9	38	12
+	+	59	117	11	41	−	57
−	+	41	188	69	49	87	87
Mean		29	80	21	25	62	
Ammonia-N/total N (%)							
+	−	23.3	15.5	19.6	34.7	−	23.3
−	−	18.6	23.3	17.2	31.3	15.2	21.1
+	+	8.0	10.7	7.8	12.1	−	8.8
−	+	9.7	8.1	7.8	9.3	9.1	8.8
Mean		14.9	14.4	13.1	21.9	12.2	

TABLE 3. EFFECTS OF ENVIRONMENTAL TEMPERATURE DURING ENSILING AND ADDING 4% MOLASSES ON ACETIC, PROPIONIC, ISO-BUTYRIC, BUTYRIC, ISO-VALERIC AND VALERIC ACID CONTENTS OF NAPIER GRASS SILAGE (g/kg DM)

Treatment		Date of harvest					
Temperature	Molasses	Jun. 26	Jul. 18	Aug. 20	Sep. 12	Oct. 21	Mean
Acetic acid content							
+	−	6.8	14.5	7.2	11.9	−	10.1
		15.4	19.1	15.1	20.8	10.3	16.1
+	+	2.5	4.2	4.9	3.5	−	3.8
−	+	3.6	4.3	3.8	4.7	4.7	4.2
Mean		7.1	10.5	7.8	10.2	7.5	
Propionic acid content							
+	−	1.5	0.4	0.5	1.6	−	1.0
−	−	1.8	2.4	1.4	1.4	0.2	1.4
+	+	0.2	0.1	0.1	0.1	−	0.1
−	+	0.1	tr	0.1	0.3	0.1	0.1
Mean		0.9	0.7	0.5	0.9	0.2	
Iso-butyric acid content							
+	−	0.04	0.01	0.03	0.14	−	0.06
−	−	0.03	0.06	0.02	0.13	tr	0.05
+	+	0.02	tr	0.01	0.01	−	0.01
−	+	0.01	tr	tr	tr	tr	tr
Mean		0.03	0.02	0.02	0.07	tr	
Butyric acid content							
+	−	2.7	0.1	2.9	5.2	−	2.7
−	−	10.0	3.1	7.5	13.6	0.3	8.6
+	+	0.5	0.1	0.1	0.2	−	0.2
−	+	0.3	tr	0.1	0.2	0.1	0.1
Mean		3.4	0.8	2.7	4.8	0.2	
Iso-valeric acid content							
+	−	0.11	0.02	0.05	0.17	−	0.09
−	−	0.07	0.10	0.03	0.23	tr	0.09
+	+	tr	0.01	0.01	0.02	−	0.01
	+	0.03	tr	tr	tr	tr	0.01
Mean		0.05	0.03	0.02	0.11	tr	
Valeric acid content							
+	−	0.01	tr	tr	0.04	−	0.01
−	−	0.02	0.05	0.01	0.04	tr	0.02
+	+	tr	tr	tr	tr	−	tr
−	+	tr	tr	tr	tr	tr	tr
Mean		0.01	0.01	tr	0.02	tr	

TABLE 4. STATISTICAL ANALYSIS BETWEEN SILAGE QUALITY, AND ENVIRONMENTAL TEMPERATURE DURING ENSILING AND ADDING MOLASSES FOR NAPIER GRASS SILAGE

	Factors			Interaction		
	Tem[1]	Mol[2]	Date[3]	Tem × Mol	Tem × Date	Mol × Date
Dry matter	ns[4]	**	*	ns	ns	ns
pH	***	***	***	***	**	*
Lactic acid	ns	*	ns	ns	ns	ns
Ammonia N/total N	ns	***	***	ns	ns	**
Acetic acid	***	***	***	***	ns	***
Propionic acid	**	***	**	**	*	**
Iso-butyric acid	ns	***	***	ns	ns	***
Butyric acid	***	***	***	***	**	***
Iso-valeric acid	ns	***	***	ns	**	***
Valeric acid	**	***	***	**	*	***

[1] Temperature, [2] Molasses, [3] Date of harvest
[4] Significant differences ***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$, ns: not significant.

210 g/kg of DM. It was a little higher than the averaged WSC content of the temperate grass.

Tropical grasses produced acetic acid type silages (Miller et al., 1966, Catchpoole and Henzell, 1971, Panditharatne et al., 1986, Ibrahim et al., 1989, Kim and Uchida, 1990), which were also produced under poor conditions for temperate grass species (McDonald, 1981). In the present experiment, however, silages which were added with molasses contained less acetic acid comparable to the levels of temperate grass silages. It was suggested that tropical grass species itself might not produce acetic acid-type silages, but less content of WSC might produce acetate-type silages. The grasses with short of WSC required for fermentation would produce acetate and butyrate and the formations of these acids were little lower in those treated with hot temperature.

It showed that high temperature might limit the unfavorable fermentations. However, the acetic acid content of the silages without molasses and treated with the temperature was still very high. Panditharatne et al. (1986) reported fermentation product of some tropical forages was mainly acetic acid and/or propionic acid. Propionic acid contents in this experiment were similar to those ensiled with temperate grass even without molasses. Little propionic acid contents was found in silages with molasses. Bolsen et al. (1986) reported that high pH values and acetic acid levels and lower lactic acid contents were found both in alfalfa and sorghum silages ensiled at 32℃ than those at 17℃. These results were similar to the present results except for acetic acid. Silages without molasses contained more than 20% of ammonia-N to total N and more 2.5% butyric acid under any temperature condition. It showed that a large amount of proteolysis occurred in silages without molasses, and pH values were increased to more than 5.

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