

Ruminal Degradation of Sugarcane Stalk

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ABSTRACT : The number of protozoa and VFA content in the rumen fluid, *in situ* disappearance and turnover rate were examined with four rumen-fistulated cattle given either sugarcane stalk or Ruzi grass hay in order to clarify the manner of rumen digestion of sugarcane stalk. Cattle were given either sugarcane stalk or Ruzi grass hay at 1.0% of body weight level with commercial concentrate feed. Feeding sugarcane stalk reduced acetate content and increased propionate and butyrate contents in rumen fluid. While rapidly-soluble fraction of sugarcane stalk was 42%, the insoluble but potentially degradable fraction was only 17%. This clearly showed that sugarcane stalk mainly consisted of water soluble fraction (i.e. sugar) and tough fiber (i.e. bagasse). The ruminal degradation rate of both Ruzi grass hay and sugarcane stalk was lower in the animal given sugarcane stalk in comparison with those given Ruzi grass hay. While the turnover rate of liquid phase was about 50% higher in the animals given sugarcane stalk than in the animals given Ruzi grass hay, that of the solid phase was about 40% lower in the animals given sugarcane stalk. The effective degradability of DM of sugarcane stalk was higher than that of Ruzi grass hay. Sugarcane would be a promising roughage for ruminants in the tropics especially, in the dry season. (*Asian-Aust. J. Anim. Sci.* 2003, Vol 16, No. 9 : 1280-1284)

Key Words : Sugarcane Stalk, Ruzi Grass, Cattle, Rumen, Turnover Rate, Disappearance

INTRODUCTION

The previous studies (Kawashima et al., 2002a and 2002b) showed that sugarcane (*Saccharum officinarum*) stalk can be used as a roughage for cattle, especially in the dry season when other fresh grass is not available. Although sugarcane stalk contains high metabolizable energy, cattle cannot consume it enough to satisfy their energy requirements when it was given as a major energy source. This is considered to be closely related to the very low digestibility of fiber in sugarcane stalk.

The present study is aimed at looking into the rumen physiology of cattle given sugarcane stalk in comparison with those given Ruzi grass (*Brachiaria ruziziensis*) hay, with special reference to turnover rate as well as *in situ* disappearance of feed in the rumen.

MATERIALS AND METHODS

Experimental design

Four castrated Brahman cattle (average body weight 407 kg) fitted with rumen fistula were used for the trial. The trial consisted of two periods. The animals were grouped

into two groups and were subjected to two dietary treatments as follows with cross-over design:

Diet 1) Ruzi grass hay 1% of body weight with commercial concentrate feed 0.5% of body weight on DM basis.

Diet 2) Sugarcane stalk 1% of body weight with commercial concentrate feed of 0.5% body weight on DM basis.

The sugarcane stalk given to the animals had been grown for more than one year and less than one and a half years, and was already matured and ready to be harvested for sending to the sugar mill. The sugarcane given to the animals was U-Tong 1 variety. The variety was developed by Suphanburi Field Crops Research Center, using polycross method with F 172, which was a female parent. This variety was registered and recommended by the Department of Agriculture, Ministry of Agriculture and Cooperatives, Thai government in 1986. The sugarcane yield is 94-125 t/ha in irrigated area and 75-94 t/ha in rain-fed area. Commercial Cane Sugar is 11-12. It has good ratooning ability. And it is resistant to smut disease and tolerant to stem borer (Boontum and Thumtong, 1997). The sugarcane stalk was cut by hand at ground level, removed top and trash, chopped with conventional forage chopper and dried under the sun. Each treatment consisted of a two-week preliminary period and a one-week trial period. The animals were housed in individual crate with free access to water. Feed was offered in two equal meals at 09:00 and 17:00 h.

Sample collection and analysis

For the first 2 days of the trial week, about 100 ml of

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Table 1. Chemical composition of feed

	DM	CP	EE	CF	Ash	NFE	NDF	ADF
	%	----- % DM -----						
Commercial concentrate	92.2	13.4	3.8	9.3	14.4	59.1	36.6	18.2
Ruzi grass hay	89.5	4.6	1.1	38.6	6.5	49.2	70.5	39.2
Dried sugarcane stalk	89.9	1.2	0.9	23.7	3.0	71.2	41.4	25.3

Table 2. Volatile fatty acid (m mol) and ammonia nitrogen (mg/dl) contents in rumen fluid of cattle given Ruzi grass hay or sugarcane stalk

Feed	Acetate (C ₂)	Propionate (C ₃)	Butyrate	Total	C ₂ /C ₃	Ammonia N
Ruzi grass hay	45.3	11.9	5.9	64.9	3.9	37.3
Sugarcane stalk	38.5**	16.2**	12.0**	68.4	2.7**	34.6
SE	1.4	1.0	0.8	2.4	0.2	3.7

** Significant difference ($p < 0.01$).

rumen fluid was taken from rumen fistula at 08:30 (30 min. before feeding), 10:00, 13:00 and 16:00 h, and strained through two layers of gauze. One ml of rumen fluid taken each time was added to 4 ml of the fixation solution containing 100 ml of formaldehyde (40% M/V), 8.5 g of NaCl and 0.3 g of Methyl green per liter of solution, and subjected to the counting of protozoa. The fluid was kept in a freezer for the analysis of VFA and ammonia-nitrogen.

A total of 24 nylon bags, which contained 3 g of either ground Ruzi grass hay or sugarcane stalk (12 bags each), were placed into the rumen of each animal in period 1. In period 2, 12 nylon bags which contained 3 g of ground Ruzi grass hay and ground sugarcane stalk were placed into the rumen of the animals given diet 1 and diet 2, respectively. Duplicated bags were taken from the rumen of each animal at 4, 8, 12, 24, 48 and 72 h after incubation. After incubation, bags were washed by hand until the water ran clear. Duplicated bags, which contained 3 g of either ground Ruzi grass hay or sugarcane stalk were also washed in the same manner to obtain 0 h wash fraction. The feed remaining in the bag was measured dry matter (DM). All the procedures followed the report of Ørskov et al. (1980).

The Cr mordants of Ruzi grass hay and sugarcane stalk, the preparation of cobalt-EDTA, and the procedure of passage rate studies were conducted according to the method of Udén et al. (1980). The marker for liquid, i.e. Co-EDTA (6 g) and the marker for solid, i.e. Cr-labeled Ruzi grass hay and Cr-labeled sugarcane stalk (5% of feed intake) for diets 1 and 2, respectively, were put into the rumen through the fistula one hour after feeding in the morning of the third day of the collection period. About 200-400 ml of ruminal content was taken from the rumen at 0, 2, 4, 8, 12, 24, 48 and 72 h after putting the markers, filtered through 6 layers of gauze. The filtered fluid was kept in the refrigerator until the analysis of cobalt. The remaining ruminal content in the cloth was dried at 60°C, and ground for the analysis of Cr.

Commercial concentrate feed, Ruzi grass hay and sugarcane stalk were subjected to the analysis of DM, crude protein (CP), ether extract (EE), crude fiber (CF) and ash by

the method of AOAC (1975), and the analysis of neutral detergent fiber (NDF) and acid detergent fiber (ADF), according to the method of Goering and Van Soest (1970). The total VFA concentration and its molar proportion in rumen fluid were measured by gas chromatograph (Shimadzu GC8A, Japan). Ammonia nitrogen in the rumen fluid was measured by a calorimetric method (Weatherburn, 1967). The number of *Entodinium spp.*, big *Ophryoscolecidae*, *Dasytricha spp.* and *Isotricha spp.* was counted using a Fuchs-Rosenthal chamber. Cobalt in rumen fluid was measured by atomic absorption spectrophotometry (Shimadzu AA625-11) with a standard addition method. The ground ruminal content for Cr analysis was ashed at 800°C and Cr was analyzed by atomic absorption spectrophotometry (Shimadzu AA625-11).

Statistical analysis

A general linear model (SAS, 1990) was used to analyze all the data. The model included diet, animal and period. For the analysis of factors calculated from the nylon bag trial, a sample in a nylon bag was additionally included in the model. A non linear regression procedure (SAS, 1989) was used to obtain the factors. A, B and C in the equation for *in situ* DM disappearance with a model: $P(\text{rumen disappearance at time } t) = A + B \times (1 - e^{-Ct})$. The effective degradability of DM was calculated as $A + B \times [C / (C + Kp)]$, where Kp = turnover rate of solid (Ørskov and McDonald, 1979).

RESULTS

Chemical composition of feed is shown in Table 1. The main difference between Ruzi grass hay and sugarcane stalk was the amount of NFE. Due to high sugar content in sugarcane stalk, the NFE was much higher in sugarcane stalk. The least square means of VFA and ammonia nitrogen contents in rumen fluid, at 30 min before feeding and 1, 4 and 7 h after feeding, are shown in Table 2. Feeding sugarcane stalk decreased acetate content and increased

Table 3. Total count and generic constitution of protozoa in rumen fluid of cattle given Ruzi grass hay or sugarcane stalk

Feed	Total count of protozoa		<i>Entodinium spp.</i>	Big <i>Ophryoscolecidae</i>	<i>Dasytricha spp.</i>	<i>Isotricha spp.</i>
	log No./ml		%	%	%	%
Ruzi grass hay	4.68		68.1	1.8	27.9	2.2
Sugarcane stalk	4.60		71.5	0.7**	24.5	3.3
SE	0.03		2.2	0.3	2.2	0.5

** Significant difference ($p < 0.01$).**Table 4.** The *in situ* disappearance of sugarcane stalk or Ruzi hay in the animals given either sugarcane stalk or Ruzi hay

Feed given Sample in bag	Ruzi	Ruzi Sugarcane	Sugarcane Ruzi	Sugarcane Sugarcane	SE	Anova		
	Ruzi	Sugarcane	Ruzi	Sugarcane		Feed	Sample	F×S
A	11.8	43.0	9.8	40.3	0.76	-	*	-
B	52.4	15.1	70.9	18.0	3.82	-	*	-
A+B	64.2	58.1	80.7	58.3	4.23	-	*	-
C	0.0274	0.0369	0.0111	0.0239	0.0040	*	-	-

P (rumen disappearance at time t) = A + B × (1 - e^{-kt}).**Table 5.** Turnover rate of liquid and solid phase in rumen, and liquid volume of cattle given Ruzi grass hay or sugarcane stalk

Feed	Turnover rate		Liquid volume /kg W ^{0.75}
	Liquid % h	Solid % h	
Ruzi grass hay	10.8	4.17	0.557
Sugarcane stalk	16.3*	2.61*	0.335
SE	1.7	0.50	0.091

* Significant difference ($p < 0.05$).

propionate and butyrate contents in rumen fluid. Consequently, the ratio of acetate to propionate was decreased by feeding sugarcane stalk. There was no difference in total VFA and ammonia nitrogen contents between the treatments.

The least square means of the total count and generic constitution of protozoa in rumen fluid, at 30 min before feeding and 1, 4 and 7 h after feeding, are shown in Table 3. The total count of protozoa (log No./ml) tended to be lower in the rumen fluid of the animals given sugarcane stalk ($p = 0.092$). Although there was no difference in the ratio of *Entodinium spp.* and *Dasytricha spp.*, the ratio of big *Ophryoscolecidae* was significantly lower and the ratio of *Isotricha spp.* tended to be higher ($p = 0.11$) in the animals given sugarcane stalk.

The DM *in situ* disappearance of sugarcane stalk and Ruzi grass hay in the rumen of animals given either sugarcane stalk or Ruzi grass hay is shown in Table 4. The A value can be interpreted as the rapidly-soluble fraction, B value the amount which in time will degrade (the insoluble but potentially degradable fraction), and C value the fractional-rate constant at which the fraction described by B will be degraded per hour. While A value was much higher in sugarcane stalk, B value was much higher in Ruzi grass hay. As the difference in B value was more than that in A, A+B was higher in Ruzi grass hay. The feed given to the animals did not affect A and B values. While C values of both Ruzi grass hay and sugarcane stalk were lower when the animals given sugarcane stalk than when those given

Ruzi grass hay.

The turnover rate of liquid and solid phases in rumen of the animals given Ruzi grass hay or sugarcane stalk is shown in Table 5. While the turnover rate of liquid phase was about 50% higher in the animals given sugarcane stalk than in the animals given Ruzi grass hay, that of the solid phase was about 40% lower in the animals given sugarcane stalk.

By using the values of *in situ* disappearance characteristics and turnover rate, the effective degradability of sugarcane stalk and Ruzi grass hay was calculated to be 48.9 and 32.6, respectively.

DISCUSSION

Previous study with lactating cows (Kawashima et al., 2002b) showed that the solid-not-fat content in the milk was improved by feeding sugarcane stalk. It was considered that the improvement of solid-not-fat content was owing both to the increase in energy intake and to the effect of sucrose in sugarcane stalk. Obara and Dellow (1993) and Obara et al. (1994) suggested that microbial fermentation of sucrose increased production of propionate, which in turn became available for glucose production, thus sparing amino acids for tissue protein utilization and reducing urea excretion. The present study confirmed the change of ruminal fermentation in animals given sugarcane stalk which contains a large amount of sucrose. Feeding with sugarcane stalk decreased acetate content and increased propionate content in rumen fluid. Consequently, the ratio of acetate to propionate was decreased by feeding sugarcane stalk.

It is generally recognized that *Ophryoscolecidae* is fond of starch and becomes dominant when the host is given large amounts of concentrate, while *Isotrichidae* is fond of water soluble sugar. As sugarcane stalk contains large amounts of sugar, mainly sucrose, there are high levels of water soluble sugar in the ration including sugarcane stalk. It was reported (Fernandez et al., 1980; Fernandez and Gill,

1980) that there was a high population of holotrich protozoa in the rumen fluid of cattle given chopped whole sugarcane. The number of big *Ophryoscolecidae* was significantly lower and the number of *Isotricha spp.* tended to be higher in the animals given sugarcane stalk in the present study, which was consistent with their report. However, the numbers of *Entodinium spp.* and *Dasytricha spp.* were not different between the treatments. Although the reason for the inconsistency in the protozoa population and its generic constitution was not clear, it would be caused by the difference in the quality and quantity of feed, as well as the performance of the animals.

The *in situ* disappearance clearly showed that sugarcane stalk consists of water soluble fraction, i.e. sugar, and tough fiber, i.e. bagasse. While the intercept of the degradation curve at time zero, i.e. rapidly-soluble fraction, was about 42%, the insoluble but potentially degradable fraction was only 17% in sugarcane stalk. Commercial Cane Sugar of this variety is generally 11-12 (Boontum and Thumtong, 1997). It means that sucrose content is about 33-40% as DM content of sugarcane stalk is about 30%. The value of rapidly-soluble fraction obtained was reasonable as sugarcane stalk also contains other kinds of sugars.

The nylon bag trial revealed another interesting aspect. The degradation rates of both Ruzi grass hay and sugarcane stalk in nylon bags were depressed by feeding sugarcane stalk. Supplementation of fibrous roughage diets with readily fermentable carbohydrates has been previously reported to depress the degradation of fiber (Mould et al., 1983). Ørskov and DeB Hovell (1977) compared the dry matter disappearance of Pangola hay from the dacron bags incubated in the rumen of cattle given either chopped whole cane or Pangola hay, and clearly demonstrated that the rate of digestion was lower in animals given sugarcane than in the rumen of animals given Pangola hay. They concluded one of the limitations with sugarcane diets is the rate of fiber digestion.

According to Leng and Preston (1988), the fiber of sugarcane is slowly digested and its long retention time in the rumen may represent a constraint to intake through distension of the rumen. The marker trial in the present trial clearly demonstrated that the rumen turnover rate of the solid phase was slower in the rumen of animals given sugarcane stalk than in those given Ruzi grass hay. The Ruzi grass hay used in the present study contained a CP of only 4.6% and was not good quality hay. Thus, the rumen turnover rate of sugarcane stalk would be much slower than that of good quality roughage produced in the temperate zone. On the contrary, the rumen turnover of the liquid phase was faster in the rumen of animals given sugarcane stalk than in those given Ruzi grass hay. Leng and Preston (1976) reported that the pH of rumen fluid in cattle given sugarcane was high and stable in the range of 7.3 to 6.8

with only minor variations. They suggested that this would be a result of high salivary flow rates since cattle were observed to spend a considerable time eating and ruminating. The stability of the pH in rumen fluid in animals given sugarcane stalk was considered to be supported by a high liquid phase turnover rate in the rumen.

Sugarcane stalk showed higher DM effective degradability and is considered to be a promising roughage for ruminants in the tropics, especially in the dry season. However, its tough fiber remains in the rumen relatively longer period, which would depress the consumption. The process of digestion would differ from other conventional roughage. It is important, therefore to establish a feeding strategy suitable to the nature of sugarcane stalk, to make its utilization more effective. For this purpose, it is necessary to identify a proper supplement, in terms of quantity and quality, and a proper combination with other roughage.

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