Feeding Value of Sugarcane Stalk for Cattle

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ABSTRACT : A metabolism trial with four castrated male Brahman cattle, average body weight 320 kg, was conducted in order to determine the nutritive value of chopped sugarcane stalk (CSS) for the establishment of feeding strategy in the dry season in Northeast Thailand. Animals were subjected to the following four dietary treatments: Treatment 1; 100% of CSS, Treatment 2; 70% of CSS and 30% of commercial complete feed (TMR), Treatment 3; 40% of CSS and 60% of TMR, and Treatment 4; 100% of TMR. The average CP, ether extracts, nitrogen free extracts, crude fiber and ash contents of CSS were 2.0, 0.9, 79.0, 16.1 and 2.2%, respectively. Although the amount of feed given was approximately at maintenance level, animals in treatments 1 and 2 refused a part of feed. The metabolism trial revealed that total digestible nutrient and metabolizable energy contents of CSS were 61.5% and 9.04 MJ/kgDM, respectively, when it was properly supplemented with protein sources. Nutritive value of CSS was lowered when animals were given CSS solely. This was due to the large loss of energy into urine and methane. Voluntary intake of CSS in cattle was not enough to satisfy energy requirement for maintenance. The CSS can be used as a roughage for feeding cattle in the dry season with proper supplementation of protein and energy. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 1 : 55-60)***

Key Words : Sugarcane Stalk, Cattle, Metabolizable Energy, Nutritive Value

INTRODUCTION

Due to the economical development in Thailand, a demand for meat and milk has been increased. The northeast region of Thailand is the center of large ruminant production in the country. While enough amount of roughage can be produced in the rainy season, ruminant production has to very much rely on rice straw in the dry season. Feed shortage in terms of quantity and quality in the dry season is a key constraint on further development of dairy production as well as beef production, which is mainly caused by harsh environment such as the shortage of water, saline soils etc. It is necessary, therefore, to exploit locally available feed resources and to develop feeding strategies compatible with the local environment in the region. In the light of this, sugarcane (*Saccharum officinarum*) may be utilized as cattle feed in the dry season. The production of sugarcane in the region has been increasing in the past decade. The preliminary study (Kawashima et al., 2001a) revealed that sugarcane in the Northeast was characterized by a relatively high ratio of stalk, and very low ratio of top. Although the top is a valuable feed resource, its availability is limited especially in the late dry season. Sugarcane stalk could be a promising roughage for feeding cattle because of its high yield under the severe environment prevailing in Northeast Thailand. The use of sugarcane stalk as cattle feed has been demonstrated in other countries (Preston, 1988). However, nutritive value, such as metabolizable energy (ME) content, of sugarcane stalk has not yet been well elucidated. This study aimed at analyzing digestion and metabolism of cattle fed chopped sugarcane stalk (CSS) and determining the nutritive value of CSS in order to set up feeding strategy for cattle in the dry season.

MATERIALS AND METHODS

Experimental design

Four castrated male cattle (Brahman), average body weight 320 kg at growing stage, were individually housed in metabolic crates with free access to drinking water. Animals were subjected to the following four dietary treatments, which were conducted in this order:

Treatment/Period 1: 100% of CSS
Treatment/Period 2: 70% of CSS and 30% of commercial complete feed (TMR)
Treatment/Period 3: 40% of CSS and 60% of TMR
Treatment/Period 4: 100% of TMR

Animals were well trained with metabolism crates and the mask for respiration trial prior to the commencement of the experiment to ensure that the animals can perform in the

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ordinal manner during the metabolism trial. One treatment consisted of nine-day preparation period and five day sampling period. Prior to the first treatment, five days of additional period was assigned to every cattle for the adaptation to the new feed.

The sugarcane used for the present study was Marcos variety (Phil.66-07). The variety had been introduced from the Philippines to Thailand, shows good germination and fast growing in the early stage, and planted mainly in northeast region in Thailand. The yield is 69-88 ton/ha and commercial cane sugar is 10-12 (Boontum and Thumtong, 1997). The sugarcane 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 for harvest. The sugarcane stalk was cut by hand at ground level and removed top and trash every three or four days and kept under shade until chopped with motor-driven conventional chopper just before given to the animals. Feed was offered in two equal meals at 08:00 and 17:00 h, and the total amount of feed was calculated from the feeding standard (Kearl, 1982) in order to satisfy total digestible nutrient (TDN) for maintenance with an assumption that the TDN content in each ration is 60%. In treatments 2 and 3, CSS and TMR were given to animals at the same time. When any CSS was refused during the collection period in treatment 1, the refusal was collected, dried at 60°C for 48 h. Then the feed consumption was calculated. The digestibility was calculated with an assumption that there was no difference between the original CSS and refused CSS. When the feed was refused during the preliminary period in other treatments, the amount was cut down so that the animals could consume all the feed.

Sample collection and analysis

The amount of feces was measured over the five day sampling period. Aliquot of feces samples were dried at 60°C for 48 h or more until no further weight decline observed, and measured as DM. Five feces samples collected from each animal during the sampling period were ground and mixed. Total amount of urine was collected into a container including hydrochloric acid and measured over the five-day sampling period. Chemical determinations of CP, ether extract (EE), crude fiber (CF) and ash were conducted on oven-dried feed and feces samples by the method of AOAC (1975). Urine samples were subjected to the analysis of nitrogen by the method of AOAC (1975). Heat of combustion of oven-dried feed and feces samples, and oven-dried (60°C for 48 h) urine were also determined using an adiabatic bomb calorimeter (Shimadzu CA-4PJ, Japan).

Oxygen consumption and methane production were measured with ventilated flow-through method using face mask during the last 4 days of the sampling period. The system consisted of face mask (Sanshin Kogyo Ltd., Japan), flow cell (Thermal flow cell FHW-N-S, Japan Flow Cell Ltd., Japan), oxygen analyzer (Model 505, Beckman Instruments, Inc., USA), methane analyzer (PA404, Servomex Ltd., UK), as described in the report of Kawashima et al. (2001b). Gas analyzers were calibrated against certified gasses (Saisan Ltd., Japan) with known gas concentrations at least two times a day. These measurements were conducted 7 times, each 6 minutes in duration, per day with the following schedule: 07:00, 10:00, 13:00, 16:00, 19:00, 22:00 and 01:00 h. Heat production (HP, kJ) was calculated by the equation, $HP=21.20\times O_2 - 6.40\times CH_4 - 5.99\times N$, where O_2 and CH_4 represent volumes of oxygen consumed and methane produced (l) at the standard temperature (0°C) and pressure (760 mmHg) and N is the quantity of urinary nitrogen excreted (g) (McLean, 1972). Digestible energy (DE) was calculated by the subtraction of energy loss into feces from gross energy (GE). The ME was calculated by the subtraction of energy losses into feces, urine and methane from GE. Energy retention was calculated by the subtraction of energy losses into feces, urine, methane and HP from GE. The retention of nitrogen was calculated by subtraction of the nitrogen excretions into feces and urine from the nitrogen intake.

Statistical analysis

A general linear model (SAS, 1990) was used to analyze all data as randomized block design. The model included dietary treatment as main factor and individual animal as block. The significant difference among the treatments was determined using Duncan's multiple range test. Data are presented as means and standard errors.

RESULTS

Chemical composition of CSS and TMR is shown in table 1. The quality of sugarcane stalk changed slightly depending on the period. The contents of CF and GE in CSS increased as the period progressed, while the content of nitrogen free extract (NFE) decreased. The ratio of CSS, CP contents of the ration and DM intake by the animals in each treatment are shown in table 2. As TMR has higher CP content than CSS, CP content differs very much depending on the level of CSS in the ration. The animals in treatments 1 and 2 could not consume all the ration. The maximum intake of CSS by animals was 36.9 $gDM/kgW^{0.75}$ with standard deviation 3.0 g from the values of DM intake in treatment 1. Apparent digestibilities of nutrients and TDN content in each ration are also shown in table 2. Higher inclusion of CSS in the ration resulted in higher digestibilities of DM, OM and NFE. Therefore, TDN content tended to be higher when the ration included more CSS, although there was no significant difference among

Table 1. Chemical composition of sugarcane stalk and commercial complete feed

	DM	CP	EE	NFE	CF	Ash	GE
	%	------------------------		%DM	------------------------		MJ/kgDM
Sugarcane stalk (Period 1)*	32.6	2.3	0.7	80.3	15.4	1.3	16.8
(Period 2)	32.8	1.4	1.0	79.5	15.5	2.7	17.3
(Period 3)	32.9	2.2	0.9	77.1	17.3	2.5	17.6
Commercial complete feed	95.3	13.7	5.9	47.5	24.8	8.2	18.9

* Period 1, 100% of sugarcane stalk was given to the animals; Period 2, 70% of sugarcane stalk and 30% of commercial complete feed was given to the animals; and Period 3, 40% of sugarcane stalk and 60% of commercial complete feed was given to the animals.

Table 2. DM intake, digestibility, TDN[1)] and energy contents of the ration including different levels of sugarcane stalk and commercial complete feed

	Treatment				S.E.	CSS[3)]
	1	2	3	4		
Ratio of CSS (%)	100.0	70.0	40.9	0.0	-	
CP content (%)	2.3	5.1	9.0	13.7	-	
DM intake (kgDM/day)	2.60	3.61	4.19	4.19	-	
Digestibility of DM (%)[2)]	56.7^{ab}	58.2^{a}	54.8^{ab}	52.4^{b}	1.6	60.3
OM	60.5^{a}	60.3^{a}	56.6^{ab}	54.4^{b}	1.5	62.2
CP	0^{d}	27.0^{c}	50.2^{b}	60.9^{a}	2.7	0
EE	19.8^{b}	80.7^{a}	85.5^{a}	87.4^{a}	3.0	64.2
CF	18.7^{c}	31.6^{ab}	28.3^{b}	37.8^{a}	2.4	24.9
ASH	0^{b}	10.3^{a}	25.5^{a}	29.6^{a}	9.8	0
NFE	71.0^{a}	69.6^{ab}	66.1^{b}	57.1^{c}	1.4	73.1
TDN content (%)	59.9	60.3	57.4	56.4	1.5	61.5
GE content (MJ/kgDM)	16.8	17.8	18.4	18.9	-	17.3
DE content (MJ/kgDM)	9.43^{a}	10.43^{b}	10.28^{ab}	10.29^{ab}	0.26	10.46
ME content (MJ/kgDM)	7.67^{a}	9.14^{b}	9.40^{b}	9.46^{b}	0.26	9.04
NE_m content (MJ/kgDM)[4)]	4.18^{a}	5.57^{b}	5.81^{b}	5.87^{b}	0.24	5.48
NE_g content (MJ/kgDM)[4)]	1.80^{a}	3.07^{b}	3.29^{b}	3.34^{b}	0.22	2.99

[1)] CSS=chopped sugarcane stalk; NE_m=net energy for maintenance; NE_g=net energy for gain; S.E., standard error.

[2)] Means of four animals. Means with different superscript letters are significantly different at $p<0.05$.

[3)] Nutrient digestibilities, GE, DE and ME contents in CSS were estimated by extrapolation of the value of treatments 2, 3 and 4.

[4)] $NE_m=1.373\times ME - 0.0330\times ME^2+0.0006\times ME^3 - 4.676$ and $NE_g=1.415\times ME - 0.0415\times ME^2+0.0007\times ME^3 - 6.92$ (Garrett, 1979).

treatments. The GE, DE and ME contents are also shown in table 2. As TMR has higher GE content than CSS, higher inclusion of TMR resulted in higher GE content. The DE content was the lowest in treatment 1 and the highest in treatment 2. The DE contents in treatments 3 and 4 were in between those in treatments 1 and 2, and there was no difference between treatments 3 and 4. The ME content of treatment 1 was significantly lower than the other treatments. Net energy for maintenance (NE_m) and for gain (NE_g) were estimated by the equation suggested by Garrett (1979). The NE_m and NE_g of treatment 1 were significantly lower than the other treatments in the similar manner as ME content. Nutrient digestibilities, and the contents of GE, DE, ME NE_m and NE_g of CSS itself were estimated by an extrapolation of data in treatments 2, 3 and 4 (table 2). As the estimated digestibilities of CP and ash were negative, those were expressed as 0%. The TDN content of CSS was calculated from these estimated digestibilities. All of estimated values were higher than the values in treatment 1.

Energy metabolism of cattle fed with different levels of CSS is shown in table 3. The GE, DE and ME intakes were the smallest in treatment 1 and followed by treatment 2. This was mainly due to the lower intake of feed by the cattle in treatments 1 and 2, and the lower energy content of the ration.

The energy loss into feces showed the same trend as the energy intake. On the other hand, the energy loss into urine was higher in treatments 1 and 4 than in treatments 2 and 3. The energy loss into methane was significantly higher in treatment 2 than treatment 4. The HP in treatment 1 was significantly lower than the other treatments. The trend of energy retention was similar to the GE intake.

The ratios of energy values are also shown in table 3. The ratio of DE to GE was not significantly different among the treatments. However, the ratio of ME to GE, metabolizability, was lower in treatment 1 than the other

Table 3. Energy and nitrogen metabolisms in cattle fed different levels of sugarcane stalk

	Treatment				S.E.
	1	2	3	4	
GE intake (kJ/kgW$^{0.75}$/day)[1)]	622^{c}	889^{b}	1061^{a}	1087^{a}	37
DE intake (kJ/kgW$^{0.75}$/day)	348^{c}	519^{b}	595^{a}	593^{a}	22
ME intake (kJ/kgW$^{0.75}$/day)	283^{c}	455^{b}	544^{a}	546^{a}	20
Energy loss (kJ/kgW$^{0.75}$/day) into					
Feces	274^{c}	370^{b}	467^{a}	494^{a}	23
Urine	25.9^{a}	13.4^{b}	13.1^{b}	22.5^{a}	2.8
Methane	39.6^{a}	50.2^{a}	37.7^{ab}	25.3^{b}	3.9
Heat production	396^{b}	433^{a}	435^{a}	424^{ab}	9
Energy retention (kJ/kgW$^{0.75}$/day)	-114^{c}	22^{b}	108^{a}	122^{a}	19
DE/GE	0.560	0.586	0.560	0.546	0.014
ME/GE	0.456^{a}	0.514^{b}	0.512^{b}	0.502^{b}	0.014
ME/DE	0.813^{c}	0.875^{b}	0.915^{a}	0.919^{a}	0.009
Urine/GE	0.041^{a}	0.015^{b}	0.012^{b}	0.021^{b}	0.004
Methane/GE	0.063^{a}	0.058^{a}	0.035^{b}	0.023^{b}	0.004
HP/GE	0.639^{a}	0.494^{b}	0.410^{c}	0.390^{c}	0.016
Nitrogen intake (g/kgW$^{0.75}$/day)	0.138^{d}	0.407^{c}	0.833^{b}	1.265^{a}	0.019
Nitrogen loss into feces(g/kgW$^{0.75}$/day)	0.157^{d}	0.299^{c}	0.415^{b}	0.495^{a}	0.019
Nitrogen loss into urine(g/kgW$^{0.75}$/day)	0.087^{b}	0.035^{b}	0.092^{b}	0.227^{a}	0.024
Nitrogen retention(g/kgW$^{0.75}$/day)	-0.106^{d}	0.074^{c}	0.326^{b}	0.542^{a}	0.031

[1)] Means of four animals. Means with different superscript letters are significantly different at $p<0.05$.

treatments. The ratio of ME to DE in treatment 1 was the lowest and that in treatment 2 was the next. The ratio of energy loss into methane to GE in treatments 1 and 2 was higher than in treatments 3 and 4. The ratio of energy loss into urine to GE in treatment 1 was higher than the other treatments.

Nitrogen balance is shown in table 3. The intake of nitrogen varied from 0.138 to 1.265 g/kgW$^{0.75}$/day. The excretion of nitrogen into feces showed similar trends as the intake. The excretion of nitrogen into urine was the highest in treatment 4. The nitrogen retention also showed similar trends as the intake.

DISCUSSION

The amount of feed given to the animals was only for maintenance. However, the animals could not consume all of CSS when CSS was included in a ration more than 70%. The calculated voluntary intake, 36.9 gDM/kgW$^{0.75}$, was lower than the values reported by Ferreiro and Preston (1977) and, Montpellier and Preston (1977). This difference would come from a complex of reasons, such as the maturity and variety of the sugarcane, environment and so on. The DM content of the sugarcane in the present study was 32.6-32.9%. Brix of the sugarcane variety used in the present study was ordinary 22-24%. Brix and DM of the sugarcane in the present study were higher than that in their trial. Other than the difference in the original sugarcane given to the animals, urea supplement in their trial would be another reason for the differences in voluntary intake. In their trial, urea and molasses mixture was added so that CP content became 12.5% in DM of the ration, while CP contents of treatments 1 and 2 in the present study were only 2.3 and 5.1%, respectively. Higher protein supplementation would have accelerated the voluntary intake. In addition to the above-mentioned differences, Leng and Preston (1976) suggested that inclusion of the cane top with the stalk increased voluntary intake. For the practical feeding of sugarcane stalk, the cane top would be better to be included in the ration.

DM digestibility of CSS was estimated to be 60.3% by the extrapolation of data in treatments 2, 3 and 4. There were several studies reporting DM digestibility of CSS or whole sugarcane, which showed a wide variation. In most studies, DM digestibility was expressed as a whole ration which included CSS and supplement such as molasses/urea mixture or rice polishing. Therefore, DM digestibility of CSS itself could not been isolated. But the amount of supplement was relatively small, the value of DM digestibility of whole ration would be similar to that of CSS itself to some extent. The DM digestibility of CSS with molasses/urea mixture was reported to be 66.7-68.2% and 70.7% in the studies of Ferreiro and Preston (1977) and Montpellier and Preston (1977), respectively. Marte et al. (1978) reported DM digestibility of CSS with urea was 60.7%. On the other hand, Ffoulkes and Preston (1978) reported that DM digestibility of whole sugarcane with molasses/urea mixture was 49.3%. The reason for the inconsistency would mainly come from maturity and variety of sugarcane, and the level of supplement.

It is generally understood that there is a positive relationship between digestibility of herbage DM and level of voluntary intake (Forbes, 1995). The voluntary intake of CSS was quite small, only 2.6 kgDM by a cattle of 320 kgW. The fiber of sugarcane, i.e. bagasse, is very tough and difficult to be digested as shown by the digestibility of CF (24.9%). It is considered that the bagasse would have been remaining in the rumen without degradation for a long period, which depressed the voluntary intake. The CSS has relatively high ME content (9.04 MJ/kg) in comparison with tropical grasses. But CSS would not satisfy energy requirement due to the limitation of intake. Thus, energy supplement may also be required especially for high performance animals when CSS is used as major roughage.

According to the Standard Tables of Feed Composition in Japan (Agriculture, Forestry and Fisheries Research Council Secretariat, 1995), CF digestibility of bagasse is 36%. On the other hand, CF digestibility of CSS in this study was 24.9%. The quality of fiber in bagasse should be basically same as that in CSS. The difference may be owing to the large content of sucrose in CSS. Supplementation of fibrous roughage diets with readily fermentable carbohydrates has been previously reported to depress the degradation of fiber (Mould et al., 1983).

In the present study, estimated value of DM digestibility (60.3%) was different from the value when animal received 100% of CSS (56.7%). There must be many factors influencing on digestibility and energy values, i.e. level of intake, nitrogen content in the ration, level of supplement etc. The values of DM and OM digestibilities, and TDN content, when the animals received CSS solely, were 94, 97 and 97% of the estimated values, respectively. While, DE, ME NE_m and NE_g were 90, 85, 76 and 60%, respectively. The ratio of ME to GE, i.e. metabolizability was the lowest when the animals received CSS solely. This was due to higher energy loss into urine and methane. It is clearly shown that proper supplementation would improve the utilization of CSS.

The energy loss into methane was negatively related to the amount of TMR in the ration. Sugarcane contains large amount of sucrose. There are some reports showing that inclusion of sucrose into feed increases propionate production (Obara et al., 1994; Sutoh et al., 1996). It is generally understood that propionate fermentation decreases methane production. This does not explain the increase of methane production by sugarcane consumption in the present study. Kurihara et al. (1997) reported that methane production per unit DM intake increased with the rise in CP content of diets from 4% to 9%. This was also different from the observation in the present study. While the level of methane production of the animals given only CSS was in the normal range (6.3% of GE), the level of the animals given only TMR was very low (2.3% of GE). The fiber in the TMR was very fine and the digestibility of DM and NFE of the TMR was relatively low. It was considered, therefore, that retention time of TMR in the rumen was relatively short and consequently methane production was suppressed when higher TMR was included in the ration.

The loss of energy into urine was the highest when animals were given CSS solely. It was accompanied with relatively higher loss of nitrogen into urine, although the animals consumed smaller amounts of nitrogen. When the animals received CSS solely, it was considered that they suffered from protein-energy malnutrition, and consequently energy was mobilized from body tissue. This tendency was recovered when they receive 30% of TMR.

The CSS contains much higher ME than rice straw (6.19 MJ/kg, Agriculture, Forestry and Fisheries Research Council Secretariat, 1995), which is the main roughage in the dry season in the region. The CSS has proved to be a good roughage in the dry season. However, it is necessary to be properly supplemented with protein and energy sources, especially in high performance animals. Further study would be required to clarify the effect of sugar on rumen fermentation and degradability of fiber in rumen for efficient use of CSS for animal production.

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