Feeding of Whole Sugar Cane to Dairy Cattle during the Dry Season

W. Suksombat* and P. Mernkrathoke

School of Animal Production Technology, Institute of Agricultural Technology, Suranaree University of Technology
111 University Avenue, Amphur Muang, Nakorn Ratchasima, 30000, Thailand

ABSTRACT : A study was conducted to determine the effect of feeding chopped whole sugar cane compared to corn silage on performances of dairy cows during the dry season. Twenty four Holstein Friesian crossbred (>87.5% Holstein Friesian) lactating dairy cows in mid lactation; averaging 16.5±2.0 kg of milk, 121±22 days in milk, 54.5±4.5 months old and 440±31 kg live weight, were stratified for milk yield, days in milk, age, stage of lactation and body weight, and then randomly allocated to two treatment groups (12 cows in each group). The first group was fed corn silage together with commercial concentrate while the second group was fed chopped whole sugar cane together with commercial concentrate. All cows consumed similar DM, however, cows on corn silage consumed more CP while cows on chopped whole sugar cane consumed more NE_{LP}. No significant differences in performances between the two groups were observed except for final live weight and body weight change. Cows on chopped whole sugar cane showed higher final live weight and gained more weight than cows on corn silage. The present study clearly indicates that chopped whole sugar cane can be fed to lactating dairy cows, while giving similar milk yield to corn silage. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 3 : 345-349)***

Key Words : Chopped Whole Sugar Cane, Corn Silage, Lactating Dairy Cows

INTRODUCTION

Roughage shortage generally occurs during the dry season in Thailand. Dairy farmers are forced to feed the lactating dairy cows with local low quality roughage such as rice straw together with an expensive meal concentrate. Such feeding regimes cause an increase in the cost of milk production. Several alternative approaches to dry-season feed management have been performed. Corn silage may satisfy the dietary needs of lactating dairy cows, but it requires sophisticated production techniques and high investment. Sugar cane is widely planted in Thailand to deliver to sugar mill for sugar production. It is easy to establish, grows quickly and is abundant in Thailand. Its ripening age corresponds with the period of low pasture availability, eliminating the need for storage and related equipment and facilities. Additional advantages of sugar cane include high biomass levels and nutritional value.

Research on feeding whole sugar cane to lactating dairy cows is very limited. Pate (1981) fed fresh chopped sugar cane to growing-finishing steer and showed that increasing levels of sugar cane in the diet resulted in less DM intake which would limit rate of gain. This response is different from that obtained with corn silage where DM intake by steer increased. It is known that sugar cane fiber has a low digestibility and may have a depressing effect on feed intake. Pate et al. (2002) reviewed several feedlot trials and indicated that fresh-chopped sugar cane may be equivalent to corn silage as a roughage source in high-concentrate diets, but has approximate 70% the value of corn silage. Fresh-chopped sugar cane was reported to be approximate 70% the value of corn silage when used as the primary ingredient in feedlot diets fed to growing cattle (Creek and Squire, 1976). One report with lactating dairy cow, Kawashima et al. (2002) fed chopped sugar cane together with rice straw or rice straw as roughage for dairy cattle and found no significant difference in milk yield between the two groups.

Chopped whole sugar cane should be used to feed to lactating dairy cows when roughages are in short supply. The aim of the present study is to determine the effect of feeding fresh cut whole sugar cane compared with corn silage on performances of lactating dairy cows.

MATERIALS AND METHODS

Twenty four Holstein Friesian crossbred (>87.5% Holstein Friesian) lactating dairy cows in mid lactation; averaging 16.5±2.0 kg of milk, 121±22 days in milk, 54.5±4.5 months old and 440±31 kg live weight, were stratified for milk yield, days in milk, age, stage of lactation and body weight, and then randomly allocated to two treatment groups (12 cows in each group). The first group was fed corn silage together with commercial concentrate while the second group was fed chopped whole sugar cane together with commercial concentrate. The experiment lasted for 10 weeks (2 weeks for adjustment period and 8 weeks for measurement period).

All cows were individually housed in a 2×3 m^2 pen and were individually fed 7.0 kg concentrate daily, divided into three equal meals, at 07:00, 11:30 and 16:30 h. Corn silage or chopped whole sugar cane were fed at *ad libitum* amounts. Corn silage was made from fresh cut corn at 85 days after sowing, which was at the milky stage as

* Corresponding Author: Wisitiporn Suksombat. Tel: +66-44-224372, Fax: +66-44-224150, E-mail: wisitpor@ccs.sut.ac.th
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appropriate for making silage. Whole sugar cane was cut at 6-7 months after planting and then chopped into small pieces of approximately 50 mm long before feeding to the cows. Feed consumptions were measured on two consecutive days each week. On the day of measuring feed intake, samples of feed offered and left after eating were taken, dried at 60°C for 36 h, ground through 1 and 2 mm screen and then kept in air tight container until used. Samples of feed ground through 1 mm sieve were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), acid detergent insoluble nitrogen (ADIN), neutral detergent insoluble nitrogen (NDIN) and ash by the method of AOAC (1990), while acid detergent fiber (ADF), neutral detergent fiber (NDF) and acid detergent lignin (ADL) by the method of detergent analysis (Goering and Van Soest, 1970). Samples of feed ground through 2 mm sieve were used to determine crude protein degradability (Ørskov and McDonald, 1979; Lindberg, 1985).

Four non-lactating dairy cows, ruminally cannulated, were used to study the nylon bag degradation. They were fed, at maintenance level, 6 kg DM of roughage mixed rations (10%CP, 9 MJ ME/kg DM), given as two equal meals per day, at 08:00 and 16:00 h. The rumen degradation value obtained by weighing approximately 3 g DM of individual sample into each of the nylon bags (80×110 mm; pore size 47 μm, Estal Mono, Switzerland). Bags were suspended in the rumen of each cow prior to the morning feeding. A bag of each sample per feed per animal was incubated in the rumen for 0, 4, 8, 12, 24, 48 and 72 h, and then removed and washed in automatic washing machine with gentle speed for 15 min., and then dried at 60°C for 36 h. After weighing each bag individually, four bags (one from each feed from each animal) of each sample were pooled to make one representative sample large enough for CP determination.

After chemical and detergent compositions were analyzed, these data were brought to calculate energy concentration in the feeds as recommended by NRC (2001) as follows.

TDN_{1X} = total digestible nutrient at maintenance level)
$= tdNFC+tdCP+(tdFA\times2.25)+tdNDF-7$

Where $tdNFC = 0.98\ (100-[NDF-NDICP)+CP+EE+Ash])$.

$tdCP_f$ (truly digestible CP for forages)
$= CP\times\exp^{[-1.2\times(ADICP/CP)]}$

$tdCP_c$ (truly digestible CP for concentrates)
$= [1-(0.4\times(ADICP/CP))]\times CP$

$tdFA = FA$ where $FA = EE-1.0$

If $EE<1$ then $FA = 0$

$tdNDF = 0.75\ (NDF_N-Lignin)\times[1-(Lignin/NDF_N)^{0.667}]$

DE_P = digestible energy at production level
$= DE_{1X}\times[TDN_{1X} -[(0.18\times TDN_{1X})-10.3])\times Intake)]/TDN_{1X}$

Where $DE_{1X} = [(tdNFC/100)\times4.2]+[(tdNDF/100)\times4.2]+[(tdCP/100)\times5.6]+[(tdFA/100)\times9.4]-0.3$

Intake = intake above maintenance

ME_P = metabolizable energy at production level
$= [1.01\times(DEp)-0.45]+0.0046\times(EE-3)$

NE_{LP} = net energy for lactation at production level
$= [0.703\times MEp)]-0.19$

All cows were milked twice a day at 05:00 and 15:00 h. Milk yields were individually recorded daily. Samples of milk from individual cow were collected on two consecutive days weekly and then subjected to laboratory analysis. Fat, protein, lactose, solid not fat (SNF) and total solid (TS) contents of milk were analyzed by Milko Scan (Foss Electric, Denmark). Live weights of all cows were individually recorded on two consecutive days immediately after morning milking at the start and at the end of the experiment.

All measured data were then subjected to analysis of variance (Steel and Torrie, 1986) using Statistical Analysis System (SAS, 1985) procedure of general linear model (GLM). Mean comparison was done using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Corn silage contained higher CP and ash contents than chopped whole sugar cane (Table 1). However, chopped whole sugar cane had higher energy values than corn silage. As the energy values reported herein derived from the estimates values recommended by NRC (2001). A summative approach was used to derive the TDN_{1X} values. In this approach, the concentrations (percent of dry matter) of truly digestible non fiber carbohydrate (NFC), crude protein (CP), ether extract (EE), and neutral detergent fibers (NDF) for each feed were estimated. The truly digestible NFC (tdNFC) was estimated by the equation: tdNFC=0.98 (100-[NDF-NDICP)+CP+EE+Ash]). Since corn silage contained higher content of ash than chopped whole sugar cane, therefore the estimated energy value of corn silage was lower than chopped whole sugar cane. When the corn silage was made, the forage harvester might pick up some surface soil together with chopped corn stem. The analyzed ash value therefore was high and caused the lower estimated all energy values. Other possible reasons for lower energy value of whole chopped sugar cane were probably due to age of harvesting, and breed of sugar cane.

Table 1. Nutrient composition (%) of feeds used in the trial

Nutrient	Concentrate	Corn silage	Chopped whole sugar cane
Dry matter	93.87	35.84	29.39
Crude protein	18.36	7.55	5.03
Crude fiber	10.30	22.81	22.71
Fat	7.87	1.19	1.17
Ash	6.68	15.14	3.71
Neutral detergent fiber (NDF)	38.22	53.01	59.95
Acid detergent fiber (ADF)	21.01	32.84	31.43
Acid detergent lignin (ADL)	2.79	5.30	6.78
Acid detergent insoluble nitrogen (ADIN)	0.85	0.50	0.18
Neutral detergent insoluble nitrogen (NDIN)	1.90	0.95	0.34
TDN_{1X} (%)[1]	75.93	51.08	58.21
DE_P (Mcal/kg DM)[1]	3.06	2.30	2.48
ME_P (Mcal/kg DM)[1]	2.64	1.87	2.05
NE_{LP} (Mcal/kg DM)[1]	1.67	1.13	1.25
dg CP	0.88	0.74	0.71

TDN_{1X}: total digestible nutrient at maintenance level = tdNFC+tdCP+(tdFA×2.25)+tdNDF-7.
DE_P: digestible energy at production level = DE_{1X} -[TDN_{1X} -[(0.18×TDN_{1X})-10.3])×Intake)]/TDN_{1X}.
ME_P: metabolizable energy at production level = [1.01×(DEp)-0.45]+ 0.0046×(EE-3).
NE_{LP}: net energy for lactation at production level = [0.703×MEp)]-0.19.
[1] Estimate recommended by NRC (2001); *dg*: degradability.

Table 2. Feed consumption of cows on the two treatment groups

Intake	Corn silage	Chopped whole sugar cane	Pr>T	SEM
DM (kg/d)				
Concentrate	6.57	6.57	-	-
Roughage	4.66	5.34	0.7592	0.78
Total	11.23	12.44	0.2195	0.47
CP (g/d)				
Concentrate	1,206	1,206	-	-
Roughage	352[a]	269[b]	0.0318	32
Total	1,558[a]	1,475[b]	0.0326	32
NE_{LP} (Mcal/d)				
Concentrate	10.97	10.97	-	-
Roughage	5.27[b]	6.68[a]	0.0001	0.20
Total	16.24[b]	17.65[a]	0.0001	0.21

Means with different superscripts within rows significantly differed.
DM: dry matter; CP: crude protein.
NE_{LP}: net energy for lactation at production level.
SEM: standard error of the mean.

Table 3. Mean performance values of cows on the two treatment groups

Details	Corn silage	Whole sugar cane	Pr>T	SEM
Milk yield (kg/d)	13.98	14.13	0.9570	0.98
4% FCM (kg/d)	12.99	12.54	0.8519	0.92
Fat yield (g/d)	493	459	0.3589	32
Protein yield (g/d)	404	428	0.1661	27
Lactose yield (g/d)	625	631	0.8809	46
SNF yield (g/d)	1,126	1,157	0.5902	74
Total solid yield (g/d)	1,620	1,617	0.9303	121
% Fat	3.53	3.25	0.1925	0.21
% Protein	2.89	3.02	0.0935	0.17
% Lactose	4.47	4.47	0.9107	0.10
% SNF	8.06	8.19	0.3084	0.28
% Total solid	11.59	11.44	0.5701	0.22
Final live weight (kg)	417[b]	448[a]	0.0495	12
Body wt. change (g/d)	-208[b]	+147[a]	0.0019	98

Means with different superscripts within rows significantly differed.
4% FCM: 4% fat-corrected-milk; SNF: solid-not-fat.
SEM: standard error of the mean.

Pate et al. (2002) reported the total digestible nutrient (TDN) value of 62.0% for fresh sugar cane which slightly higher than reported in the present study (58.2%). Crude protein, NDF and ADF contents of chopped whole sugar cane in the present study were higher than those reported by Van and Ledin (2002). The differences were probably due to differences in breed of sugar cane, soil type, fertilizer application and age of harvesting.

All cows consumed similar DM (p>0.05), however, cows on corn silage consumed more roughage CP and total CP than cows on chopped whole sugar cane (p<0.05) while cows on chopped whole sugar cane consumed more NE_{LP} than cows on corn silage (p<0.01). The reasons for these are that corn silage contained more CP while chopped whole sugar cane contained more NE_{LP}.

There were no significant differences in performance between the two groups (p>0.05) except for final live weight and body weight change. Cows on chopped whole sugar cane had higher final live weight (p<0.05) and gained more weight (p<0.01) than those cows on corn silage. Kawashima et al. (2002) fed chopped sugar cane together with rice straw or rice straw alone as roughage for dairy cattle and found no significant difference in milk yield between the two groups. However, they found higher solid-not-fat of cows given chopped sugar cane stalk.

By combing the data for milk yield and live weight change, it was possible to compare the influence of different roughages on the apparent utilization of NE_{LP} intake (Table

Table 4. Estimates of the partitioning of net energy intake

	Corn silage	Whole sugar cane	Pr>T	SEM
NE_{LP} intake (Mcal/d)	16.24[b]	17.65[a]	0.0001	0.21
NE_{LM} (Mcal/d)	7.46	7.74	0.4002	0.32
NE_{LG} (Mcal/d)	-1.02[b]	0.76[a]	0.0018	0.49
NE_{LL} (Mcal/d)	9.30	9.14	0.5250	0.34
NE_{LR} (Mcal/d)	15.74[b]	17.64[a]	0.0491	0.85
Efficiency of energy utilization	0.97	1.00	0.7462	0.05

Means with different superscripts within rows significantly differed.
NE_{LP}: net energy for lactation at production level.
NE_{LM}: net energy requirement for maintenance = $0.08\times LW^{0.75}$.
NE_{LG}: net energy requirement for gain = reserve energy×(0.64/0.75).
NE_{LL}: net energy requirement for lactation = 0.0929×% fat+0.0547×% CP+0.0395×% lactose.
NE_{LR}: net energy retention; SEM: standard error of the mean.

Table 5. The estimated supply of rumen degradable protein and rumen undegradable protein

	Corn silage	Whole sugar cane	Pr>T	SEM
RDP_{req} (g/d)	1,169[b]	1,327[a]	0.0449	60
RDP_{sup} (g/d)	1,262[a]	1,173[b]	0.0146	16
Deficit/surplus (g/d)	+93[a]	-154[b]	0.0267	49
UDP_{req} (g/d)	440	520	0.6294	53
UDP_{sup} (g/d)	296	302	0.9200	20
Deficit/surplus (g/d)	-144	-218	0.0429	54

Means with different superscripts within rows significantly differed.
RDP_{req}: rumen degradable protein requirement = 0.15294×TDN act total.
RDP_{sup}: rumen degradable protein supply = total DM fed×1,000×diet CP×CP_RDP.
RUP_{req}: rumen undegradable protein requirement = total CPReq-(MP Bact+MP Endo)/diet RUPDigest.
RUP_{sup}: rumen undegradable protein supply = CP Toal-RDP_{sup}.
SEM: standard error of the mean.

4). Although the cows on chopped whole sugar cane consumed more NE_{LP} than the cows offered corn silage, the partitioning of energy to milk production and maintenance was similar. Agnew and Yan (2000) reviewed recent research on energy utilization by dairy cattle and suggested that many factors affected the partition of energy between milk and body tissue. These include genetic parameters, milk yield, body state, previous nutritional history, stage of lactation, plane of nutrition, diet composition, method of feeding and even interactions between these factors. Of importance, plane of nutrition, for example, level of feeding and/or level of energy intake are the major contribution to difference in partitioning of energy between milk and body tissue. At low energy intakes there is a large response in partition of energy in to milk and little response in to body tissue, yet at high energy intakes the opposite effect is obtained. The present study showed that cows on corn silage consumed less energy than cows on fresh cut whole sugar cane. In addition, cows on corn silage lost weight while cows on chopped whole sugar cane gain weight. This might suggest that the energy intake of cows on corn silage was partitioned towards the milk output rather than body tissue.

Although there were no significant differences in milk composition, milk protein of cows given chopped whole sugar cane tended to be higher than those cows given corn silage. Sutton (1989) suggested that increasing energy intake is the most reliable means of increasing milk protein concentration. In the present study, the cows on chopped whole sugar cane consumed more NE_{LP} than cows on corn silage. There were some reports suggesting that sucrose supplementation resulted in an improvement in the efficiency of nitrogen retention in sheep (Obara et al., 1994; Sutoh et al., 1996). Obara et al. (1994) reported that sucrose supplementation resulted in a decrease in the urinary nitrogen excretion rate and therefore an increase in nitrogen retention, which was accompanied with decreases in the ammonia concentration in the rumen and the plasma urea concentration.

Using the protein degradability values of each feed (determined by nylon bag technique), the estimated supplies of rumen degradable protein (RDP) and rumen undegradable protein (UDP) to the cows was calculated (Table 5; NRC, 2001). The cows on corn silage ration consumed more RDP than the cows on chopped whole sugar cane ration but consumed similar UDP. Cows on corn silage received adequate RDP but inadequate UDP while cows on chopped whole sugar cane consumed inadequate RDP and UDP. The deficit in RDP supply relative to demand would have reduced microbial protein synthesis and thus a low quantity of microbial protein would have reached the small intestine. Both microbial protein and digestible UDP are rich in essential amino acids (Oldham, 1984), if absorbed amino acids are in short supply, the excess of energy-yielding nutrients will then be either stored as fat or oxidized. If excess nutrients were to be stored as fat, then milk production might be less than optimal, but the efficiency of use of energy for milk plus tissue deposition would be little affected (ARC, 1980). If excess nutrients were to be oxidized, then it might be expected that the efficiency of utilization of energy for milk production plus tissue deposition would fall (Oldham, 1984). In the present study, the excess energy intake of cows on fresh cut whole sugar cane may be stored as fat, then milk production might be less than would have been expected from energy intake. However, the energy intake of cows on corn silage may be oxidized, thus it might be expected that the efficiency of utilization of energy for tissue deposition would fall. Therefore, feeds of higher CP degradability, such as urea, are needed to increase RDP supply while feeds containing bypass protein such as cotton seed meal are needed to increase UDP supply.

In the nutritional point of view, the present study clearly showed that chopped whole sugar cane can be used as roughage for lactating dairy cows. However, the utilization of whole sugar cane as roughage for dairy cows highly depends on the cost of sugar cane and the harvesting and feeding methods.

IMPLICATION

The present study clearly indicates that chopped whole sugar cane can be used as roughage for lactating dairy cows particularly when other roughages are in short supply. Costs of sugar cane and harvesting should be taken into account when whole sugar cane was fed as roughage for dairy cows.

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