Cassava Chips and Ground Corn as Sources of Total Non-Fiber Carbohydrates in Total Mixed Rations for Dairy Cows[a]

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ABSTRACT : Six Holstein × indigenous multiparous dairy cows, 60±8 days in milk, were used in a double 3×3 Latin square design to investigate the efficiency of milk production. The dairy cows were randomly allocated to total mixed rations (TMR) containing ground corn, ground corn plus cassava chips 50:50 and cassava chips as main sources of total non-fiber carbohydrates. Ether extract and calculated energy intakes for dairy cows fed TMR containing cassava chips were lower ($p<0.05$) than those fed TMR containing ground corn and ground corn plus cassava chips 50:50. There were no differences ($p>0.05$) in daily DM intake (3.51, 3.41 and 3.29% BW), in 4% fat corrected milk (19.66, 20.59 and 20.23%), in milk protein (3.37, 3.27 and 3.33%), and in solids-not-fat (9.03, 8.90 and 8.99%) but there were differences in cost of diets per kg of 4% fat corrected milk (40.75, 34.33 and 28.17%; $p<0.01$) for dairy cows fed TMR containing ground corn, ground corn plus cassava chips 50:50, and cassava chips. It can be concluded that the efficiency of milk production (4% fat corrected milk per dry matter intake) for dairy cows fed TMR containing cassava was greater than for those fed TMR containing corn. (*Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 2 : 206-210*)

Key Words : Cassava, Corn, Dairy Cows, Milk, Total Non-Fiber Carbohydrates

INTRODUCTION

Cassava pellets and chips are the major products produced from the roots of cassava plants (*Manihot esculenta Crantz*). Cassava contains 650-850 g of total non-fiber carbohydrates (TNFC) per kg dry matter (DM) and has been used extensively as a feed for livestock (Kanjanapruthipong, 2000). Total non-fiber carbohydrates of cassava are easily degraded within the rumen of cattle and 2-3 times more degraded *in vitro* (Cone et al., 1989) and *in sacco* (Tamminga et al., 1990) than those of corn. Cassava is an excellent source of fermentable TNFC which are energy yielding substrates for the microbial population in the rumen (Kanjanapruthipong, 2000).

Cassava contains 20-30 g of crude protein (CP) per kg DM which may be a limiting factor for a ruminant feed (Kanjanapruthipong, 2000). Inclusion of cassava in low quality roughage diets without an additional source of nitrogen will impair microbial growth efficiency (Premaratne et al., 1998) due mainly to an insufficient supply of nitrogen for microbial protein synthesis (Leng et al., 1993). An increased efficiency of microbial synthesis by 23.1 g of nitrogen per kg of organic matter fermented in the rumen was observed in steers fed cassava-based diets with a sufficient supply of preformed-protein and urea (Zinn and DePeter, 1991). A similar result (23.9 g of microbial N per kg of cassava DM fermented) was also observed in an *in vitro* study when nitrogen from urea was added at the level of 20 g of urea-N per kg of soluble fraction of TNFC found in cassava (Kanjanapruthipong, 2000). These results suggest that an adequate supply of nitrogen is necessary when cassava is used as a source of TNFC for ruminants.

Without the inclusion of urea, milk production of dairy cows fed diets containing cassava as a main source of TNFC was slightly greater compared with milk production of dairy cows fed diets containing barley (Brigstocks et al., 1981) and oats (Mathur et al., 1969). Growth rates in steers fed cassava-based diets with the inclusion of ground nut meal, meat and bone meal and fish meal as nitrogen sources were similar to those fed cassava-based diets with the inclusion of urea (Tudor et al., 1985). Although the price of cassava with an adjustment of CP by adding urea at the level of 20 g of urea-N per kg of soluble fraction of TNFC found in cassava is relatively very low (Kanjanapruthipong, 2000), milk production in dairy cows fed diets containing the protein-adjusted cassava as a main source of TNFC has not been reported. The study reported here was conducted to examine the efficiency of milk production in dairy cows fed TMR containing the protein-adjusted cassava chips as a main source of TNFC.

MATERIALS AND METHODS

Six Holstein × indigenous (93.5 × 6.25%) multiparous dairy cows, 60±8 days in milk, were randomly allocated to dietary treatments according to a double 3

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[a] Supported by Thai Tapioca Development Institute, Bangkok, Thailand.
Received August 2, 2000; Accepted October 19, 2000

×3 Latin square design with 28 d periods.

Total mixed rations (TMR), containing ground corn (GC), ground corn plus cassava chips 50:50 (GC+CC) and cassava chips (CC) as main sources of TNFC, were formulated as shown in table 1. Paragrass hay was made from well manure-fertilized perennial paragrass. Crude proteins of ground corn and cassava chips were adjusted to be approximately 12% CP using 25 g and 20 g nitrogen from urea per kg of soluble fraction of TNFC found in ground corn and cassava chips, respectively, as recommended by Kanjanapruthipong (2000). Protein and energy contents for the experimental diets were adjusted following the NRC (1988) recommendation.

Total mixed rations were offered *ad libitum* in equal portion at 05.00, 08.00, 16.00 and 18.00 h. The experimental diets were sampled weekly and bulked for later chemical analysis. Within the 28 d experimental period, the first 4 d was regarded as a transitional period, the following 10 d as an adaptation period and in the last 14 d milk sampling was undertaken. Over the last 14 d in each period, intake and milk yield were recorded daily and milk samples were taken every 3 d intervals from each cow at each milking in a sampling day. Milk samples of 50 ml were collected in bottles containing 2-bromo-2-nitro-1,3-propadiol and stored at 5℃ for later analysis. Animal live weights were recorded after the morning milking at the beginning of the experiment and the end of each period.

Crude protein (CP), ether extract (EE), ash and DM contents of the experimental diets were determined according AOAC (1980). Neutral detergent fiber (NDF) and neutral detergent insoluble nitrogen (NDIN) were measured following the method of Van Soest and colleague (1991). Total non-fiber carbohydrates (TNFC) was calculated following the equation TNFC=100-CP-EE-(NDF-NDIN)-ash. Milk composition was determined by MilkoScan (Foss Electric, Denmark). Statistical analysis was carried out by SAS (1989).

RESULTS

Values of nutrient composition on a DM basis for ground corn and cassava chips were as follows: CP, 8.04 and 2.45%; EE, 6.05 and 1.61%; NDF, 18.54 and 8.46%; NDIN, 0.54 and 1.68%; TNFC, 65.41 and 80.16%; ash, 1.42 and 5.64%; and DM, 88.08 and 89.3%.

Chemical composition of the experimental diets is presented in table 1. Protein and TNFC contents for TMR containing cassava chips were slightly higher than those containing ground corn plus cassava chips 50:50 and ground corn. However, EE, NDF and calculated energy (NRC, 1988) contents for TMR containing cassava chips were slightly lower than those containing ground corn plus cassava chips 50:50 and ground corn. Costs of TMR containing ground corn, ground corn plus cassava chips 50:50 and cassava chips were 0.11, 0.10 and 0.08 US$/kg, respectively (table 1).

Treatment effects on live weight and nutrient intake are presented in table 2. Daily gain and intakes of DM, CP and TNFC of dairy cows fed TMR containing ground corn, ground corn plus cassava chips 50:50 and cassava chips were not significantly different ($p>0.05$). However, daily intakes of EE, NDF and energy for dairy cows fed TMR containing ground corn and ground corn plus cassava chips 50:50 were significantly higher than those fed TMR containing cassava chips ($p<0.05$).

Milk composition, yield and 4% fat corrected milk for dairy cows fed TMR containing ground corn, ground corn plus cassava chips 50:50 and cassava chips were not significantly different ($p>0.05$; table 3). However, costs of diets in relation to income per kg of 4% fat corrected milk for dairy cows fed TMR containing ground corn, ground corn plus cassava chips 50:50 and cassava chips were significantly different ($p<0.01$): 40.75, 34.33 and 28.17%, respectively (table 3).

DISCUSSION

The range of undegraded intake protein (UIP) in diets for dairy cows recommended by NRC (1988) is from 34 to 37% of CP. In this study, UIP calculated from data of NRC (1988) were 34, 30 and 26% of CP for TMR containing ground corn, ground corn plus cassava chips 50:50 and cassava chips, respectively. Total mixed ration containing ground corn, in this study, will meet the UIP requirement. However, effects on UIP of dairy cow performance reported in the literature are not consistent, perhaps reflecting an imbalance in absorbed amino acid profile and a decrease in microbial protein synthesis (Santos et al., 1998).

In general, rate of digestion of carbohydrates is the major factor controlling the energy available for growth of rumen microbes (Hoover and Strokes, 1991). Oats, cassava, wheat and barley contain high soluble fractions of starch and sugar (Tamminga et al., 1990) and can be added to diets to increase utilization of ruminal ammonia-N for microbial protein synthesis (Casper and Schingoethe, 1989; Stern et al., 1978). Microbial N entering the small intestine in steers fed flaked corn- and cassava-based diets was 86 and 94.1 g/d (Zinn and DePeter, 1991) and in steers fed dry rolled sorghum, dry rolled corn and dry rolled barley based diets, it was 76, 81 and 112 g/d, respectively (Spicer et al., 1986). In an *in vitro* study with various levels of nitrogen from urea, the highest growth rate of rumen microbes was 23.9 g N/kg of cassava DM digested when nitrogen from urea was 20 g/kg of soluble fraction of TNFC found in cassava. This is in accordance with 23.1 g per kg of organic matter fermented in steers fed cassava-based diets as reported by Zinn and DePeter (1991). In this study, microbial N leaving the rumen of dairy cows fed TMR containing cassava chips is likely to be higher than those fed TMR containing ground corn.

It is generally accepted that cassava is a highly palatable feed. However, effects of inclusion rates of cassava in diets for cattle on feed intake reported in literature were not consistent. In steers fed TMR containing various rates of substitution of cassava for steam-flaked corn, maximal intake was observed when the rate of substitution of cassava was at the 15% level (Zinn and DePeter, 1991). Daily intake in steers fed TMR containing dry rolled sorghum was significantly higher than in those fed TMR containing cassava (Tudor et al., 1985). In dairy cows fed barley- and cassava-based diets, daily intake was not different (Brigstocke et al., 1981). Increased daily intake was associated with increased rates of substitution of cassava for oats in diets for dairy cows (Mathur et al., 1969). In this study, decreased daily intake in dairy cows was observed when rates of inclusion of cassava chips in the diets were increased (table 2).

Although an increase in levels of ground corn in TMR is associated with a decrease in efficiency of starch digestion in the small intestine (Karr et al., 1966), starch digested at the small intestine is used more efficiently for milk synthesis than that digested in the rumen (Nocek and Tamminga, 1991). However, other studies (Casper and Schingoethe, 1989; MacGregor et al., 1983; Casper et al., 1990) have reported greater or similar milk production by dairy cows fed diets containing more fermentable TNFC in the rumen compared with the production of cows fed ground corn plus soybean meal diets. Although energy and NDF intakes of dairy cows fed TMR containing cassava chips reported in this study were lower, conversion of diets to 4% fat corrected milk increased by 15 and 6.5% for dairy cows fed TMR containing

Table 1. Ingredients and chemical composition of diets containing ground corn (GC), ground corn plus cassava chips 50:50 (GC+CC) and cassava chips (CC) as sources of TNFC

	Price US$/kg	Diets		
		GC	GC+CC	CC
Ingredients				
Soy bean meal	0.22	5.25	5.25	5.25
Cotton seed meal	0.11	15.0	15.0	15.0
Whole cotton seed meal	0.11	6.0	8.625	11.25
Ground corn	0.14	39.75	19.875	-
Cassava chips	0.07	-	18.0	36.0
Molasses	0.05	5.25	4.2	3.15
Urea	0.13	0.6	0.9	1.2
Monocalcium phosphate	0.40	0.75	0.75	0.75
Dicalcium phosphate	0.38	0.75	0.75	0.75
$CaCO_3$	0.02	0.525	0.525	0.525
$NaHCO_3$	0.40	0.525	0.525	0.525
NaCl	0.06	0.375	0.375	0.375
Premix	1.24	0.225	0.225	0.225
Paragrass hay	0.03	25	25	25
Total		**100**	**100**	**100**
Chemical composition				
Crude protein, %		16.03	16.13	16.24
Ether extract, %		3.97	3.55	3.13
Neutral detergent fiber, %		30.26	29.04	27.81
Neutral detergent insoluble nitrogen, %		0.08	0.99	1.07
Total non-fiber carbohydrates, %		37.36	38.75	40.14
Total digestible nutrients, %		69.24	67.97	66.70
Metabolizable energy* (Mcal/kgDM)		2.63	2.58	2.52
Net energy for lactation** (Mcal/kgDM)		1.58	1.55	1.51
Cost of diets, US$/kg		0.11	0.10	0.08

* DE=O-04409×TDN(%) and ME(Mcal/kgDM)=-0.45+1.01 DE.

** NEL (Mcal/kgDM)=(0.0245TDN) 0.12.

cassava chips and ground corn plus cassava chips 50:50, compared with that for dairy cows fed TMR containing ground corn.

In this study, CP of cassava chips and ground corn were adjusted to be approximately 12% by adding 20 and 25 g nitrogen from urea per kg of

Table 2. Live weight changes and voluntary intake of diets containing ground corn (GC), ground corn plus cassava chips 50:50 (GC+CC) and cassava chips (CC) as sources of TNFC

	Diets			SE
	GC	GC+CC	CC	
Live weight changes				
Initial weight, kg	496	495.3	497	23.11
Final weight, kg	491	501	494.3	48.77
Average weight, kg	493.5	498.2	495.7	48.03
Daily gain, g/d	-179	204	-96	0.57
Voluntary intake				
Dry matter intake, kg/d	17.30	17.01	15.49	0.85
Dry matter intake, % BW	3.51	3.41	3.29	0.04
Crude protein intake, kg/d	2.77	2.74	2.52	0.09
Ether extract intake, kg/d	0.69[a]	0.60[a]	0.48[b]	0.12
Neutral detergent fiber intake, kg/d	5.23[a]	4.94[a]	4.31[b]	0.41
Total non-fiber carbohydrates intake, kg/d	6.46	6.59	6.22	0.03
Total digestible nutrient intake, kg/d	11.98[a]	11.56[a]	10.33[b]	0.30
Metabolizable energy intake, Mcal/d	45.50[a]	43.89[a]	39.03[b]	2.01
Net energy for lactation intake, Mcal/d	27.33[a]	26.37[a]	23.39[b]	1.82

[a,b] Means within a row without a common superscript letter differ ($p<0.05$).

Table 3. Milk composition and yield, 4% fat corrected milk and cost of diet in relation to income per kilogram of 4% fat corrected milk of dairy cows fed diets containing ground corn (GC), ground corn plus cassava chips 50:50 (GC+CC) and cassava chips (CC) as sources of TNFC

Milk composition and yield	Diets			SE
	GC	GC+CC	CC	
Butter fat				
- %	4.15	4.32	4.27	0.07
- kg/d	0.80	0.85	0.83	0.35
Milk protein				
- %	3.37	3.27	3.33	<0.01
- kg/d	0.65	0.64	0.65	0.02
Lactose				
- %	4.97	4.93	4.96	0.01
- kg/d	0.96	0.97	0.96	0.09
Minerals				
- %	0.70	0.70	0.70	<0.01
- kg/d	0.13	0.1364	0.1353	0.01
Solid not fat				
- %	9.03	8.90	8.99	0.01
- kg/d	1.7374	1.75	1.75	0.34
Total solid				
- %	13.19	13.23	13.26	0.10
- kg/d	2.54	2.60	2.58	0.31
Milk yield, kg/d	19.23	19.64	19.44	0.08
Fat corrected milk (4%), kg/d	19.66	20.59	20.23	0.90
Cost of diet/income from kilogram of 4% fat corrected milk*, %	40.75[1]	34.33[1,2]	28.17[2]	0.03

* Price of 4% fat corrected milk=0.27 US$/kg.

[1,2] Means within a row without a common superscript letter differ ($p<0.01$).

soluble fraction of TNFC found in cassava and corn as recommended by Kanjanapruthipong (2000). Price of the protein-adjusted cassava was approximately 40-96% cheaper than the protein-adjusted corn. This lower price led to 27 and 9% cheaper costs of TMR containing cassava chips and ground corn plus cassava chips 50:50 than of TMR containing ground corn. The lower cost of TMR together with the higher feed conversion as mentioned above resulted in lower cost of diets in relation to income per kg 4% fat corrected milk, which was 28.17, 34.33 and 40.75% for dairy cows fed TMR containing cassava chips, ground corn plus cassava chips 50:50 and ground corn, respectively (table 3).

An adjustment of CP content of cassava by adding 20 g of urea-N per kg of soluble fraction found in cassava can be used as a main source of TNFC in dairy feed. The results support the conclusion that the efficiency of milk production in dairy cows fed TMR containing the protein-adjusted cassava as a main source of TNFC is greater than that in dairy cows fed TMR with a similar nutritional specification not containing cassava. Savings from the inclusion of cassava certainly vary according to prevailing raw material prices and methods of CP adjustment.

ACKNOWLEDGMENT

The authors acknowledge the receipt of a research grant from Thai Tapioca Development Institute (TTDI), Bangkok, Thailand.

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