ENERGY AND PROTEIN EVALUATION OF FIVE FEEDS-TUFFS USED IN DIET IN WHICH CASSAVA PULP AS MAIN ENERGY SOURCE FOR LACTATING DAIRY COWS

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Abstract

Energy values of five feedstuffs commonly used in the concentrates were evaluated. The energy values, net energy for lactation at production level (NE_{LP}), were 1.48 ± 0.01, 1.44 ± 0.01, 1.65 ± 0.01, 1.85 ± 0.01 and 2.00 ± 0.01 for cassava chip, cassava pulp, rice bran, ground corn and soybean meal, respectively. The experiment was then conducted to investigate the effect of cassava pulp addition in the concentrate on the performance of lactating dairy cows. Twenty four Holstein Friesian crossbred (>87.5% Holstein Friesian) lactating dairy cows in mid lactation; averaging 13.2 ± 2.1 kg of milk, 114 ± 42 days in milk, 48.2 ± 7.0 months old and 437 ± 55 kg live weight, were stratified for milk yield, days in milk, age, stage of lactation and body weight, and then randomly allocated to three treatment groups. The first, second and third groups were fed concentrates containing the respective cassava pulp, 35%, 40%, and 45%. All cows were fed *ad libitum* grass silage and given free access to clean water. Dry matter intake (15.3 vs 15.8 kg/d), milk yield (14.2 vs 14.1 kg/d), milk composition and body weight change were unaffected (P>0.05) by the treatments. The present study indicated that 45% cassava pulp can be used in the concentrate for lactating dairy cows.

Keywords: Cassava pulp, energy evaluation, milk production, dairy cattle

Introduction

In Thailand, more than 60% of the cost of milk production is the cost of feeds, particularly concentrates. Increases in the cost of feeds inevitably cause increases in the cost of milk production. In addition, the increase in demand for renewable energy has affected the price of livestock feeds such as cassava chip and molasses since they are the major raw materials for ethanol production. Both feedstuffs have risen in price to the point where there is interest in reducing the level consumed by the animals. There are many attempts to reduce cost of feeds through the utilization of cheap raw materials, such as agro-industrial by-products. Although cassava pulp, the residue obtained after the extraction of starch from cassava roots, is low in crude protein (CP), it is present in a considerable amount. Sriroth (2006) reported

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that approximately 1.5 million tons of cassava pulp was produced from 20 million tons of cassava roots in Thailand in 2005. The reported nutritive values of cassava pulp were 56% starch, 5.3% CP and 35.9% crude fiber (Tesfa, 2006). The research on cassava pulp as lactating dairy cattle feeds is very limited. The aims of this study were to evaluate the energy values of feedstuffs commonly used in the concentrates and to determine the effect of replacing ground corn by cassava pulp in the concentrates on the performance of lactating dairy cows.

Materials and Methods

Fifteen samples of each of five feedstuffs, cassava chip, cassava pulp, ground corn, soy bean meal and rice bran, were collected from various feed mills in the south of the Northeastern region of Thailand. They were then ground through 1 and 2 mm sieve and were subjected to proximate and detergent analyses. Samples of feed ground through 1 mm screen were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), neutral detergent insoluble nitrogen (NDIN), acid detergent insoluble nitrogen (ADIN) and ash by method of AOAC (1995), and for neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) by the method of detergent analysis (Van Soest *et al*., 1991).

Energy values were evaluated using equations recommended by the NRC (2001) as follow:

TDN_{1X} = total digestible nutrient at maintenance level

= tdNFC + tdCP + (tdFA × 2.25) + tdNDF – 7

where tdNFC (truly digestible non-fiber carbohydrates)

= 0.98 (100 - [(NDF – NDICP) + CP + EE + Ash])

tdCPf (truly digestible CP for forages)

= $CP \times \exp^{[-1.2 \times (ADICP/CP)]}$

tdCPc (truly digestible CP for concentrates)

= [1 – (0.4 × (ADICP/CP))] × CP

tdFA (truly digestible fatty acid)

= FA where FA = EE – 1.0, If EE<1.0 then FA = 0

tdNDF (truly digestible neutral detergent fiber)

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

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) × 4.2] + [(tdNDF/100) × 4.2] + [(tdCP/100) × 5.6] + [(FA/100) × 9.4] –0.3

Intake = intake above maintenance

ME_P (metabolizable energy at production level)

= $[1.01 \times (DE_P) - 0.45] + [0.0046 \times (EE - 3)]$

NE_{LP} = $[0.703 \times ME_P\ (Mcal/kg)] - 0.19$

Five samples of each feed ground through 2 mm sieve were used to determine DM and CP degradability (Linberg, 1985). Four non-lactating dairy cows, ruminally equipped with cannulae were used to study the nylon bag degradation. They were fed, at maintenance level, 5 kgDM of total mixed ration (10%CP, 2 Mcal metabolizable energy (ME)/kgDM), given as two equal meals per day, at 08:00 and 16:00 h. The rumen degradation values were obtained by weighing approximately 3 gDM of individual sample into each of the nylon bags (80 × 110 mm; pore size 47 mm, 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 an automatic washing machine at a low 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 obtaining the chemical composition, the energy and protein values of feedstuffs, the experiment was conducted to investigate the effect of cassava pulp addition in the concentrate on the performance of lactating dairy cows. Twenty four Holstein Friesian crossbred (>87.5% Holstein Friesian) lactating dairy cows in mid lactation; averaging 13.2 ± 2.1 kg of milk, 114 ± 42 days in milk, 48.2 ± 7.0 months old and 437 ± 55 kg live weight, were stratified for milk yield, days in milk, age, stage of lactation and body weight, and then randomly allocated to three treatment groups (8 cows in each group). The first group was fed concentrate containing 35% cassava pulp, the second group was fed concentrate containing 40% cassava pulp, and the third group was fed concentrate containing 45% cassava pulp. All cows were fed *ad libitum* grass silage and given free access to clean water. The experiment lasted for 10 weeks (2 weeks for an adjustment period followed by 8 weeks for the measurement period).

All cows were individually housed in a 2 × 3 m^2 pen and were individually fed 8.0 kg concentrate daily divided into three equal meals at 07:00, 11:30, and 16:30 h. A basal diet, grass silage, was fed at *ad libitum* amounts after concentrate feeding. Grass silage was made from fresh cut guinea grass (*Panicum maximum*) at 45 d after last cutting, which was at the age appropriate for making silage. Feed consumptions were measured on two consecutive days each week. Samples of feed offered and orts were taken and were analyzed as previously described.

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 cows were collected on two consecutive days weekly and then subjected to laboratory analysis (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, 1996) procedure of general linear model (GLM). Mean comparison was done using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Chemical Composition and Energy Evaluation of Feedstuffs

Chemical composition, energy values, rumen degradable protein, rumen undegradable protein and degradability of CP of feedstuffs are summarized in Table 1. As expected, soybean meal had a higher CP content than other feeds. Rice bran showed a high EE, ash, and CF. Cassava pulp and cassava chip had very low CP and EE when compared to other feeds. However, analyzed values of chemical composition of the feeds are in the range widely reported (Khang *et al*., 2000; NRC, 2001; Preston, 2004). Sriroth *et al*. (2000) reported chemical composition of cassva pulp as follows: 1.55% CP, 27.75% CF, 0.12% EE, 1.70% ash and 68.89% starch. Furthermore, Nitipot and Sommart (2003) reported 1.64% CP, 1.79% ash, 25.65% NDF and 17.79% ADF. Ground corn had highest TDN_{1X} while soybean meal showed highest DE_{1X}. However, when NE_{LP} is taken into account, the values shown in descending order are soybean meal (2.00), ground corn (1.85), rice bran (1.65) cassava chip (1.48) and cassava pulp (1.44) which are close to other reports (NRC, 2001). Variations in chemical composition and energy values reflect the differences in breeds, harvesting processes, soil types, fertilizer applications, weather, season etc.

Utilization of Cassava Pulp as Energy Source in the Concentrate for Dairy Cows

Chemical and nutrient compositions of feeds used in the experiment are given in Table 2. CP and EE slightly decreased as the level of cassava pulp in the concentrates increased. In contrast, CF, NDF and ADF increased with increasing cassava pulp level in the concentrates. Energy values were reduced with increasing levels of cassava pulp addition. This can be attributed to higher CP, EE and energy values, and less fiber content of ground corn than cassava pulp. The present study replaced ground corn with cassava pulp.

All cows consumed similar DM, CP and NE_{LP} intakes of concentrate, grass silage and total diet (Table 3). There were no significant differences in performance among the treatment groups (Table 4).

Research on feeding concentrates containing cassava pulp to lactating dairy cows is very limited. Sommart and Bunnakit (2004) fed Brahman or Charolais-Brahman crossbred yearling beef cattle with concentrates containing 50% cassava chip, 50% cassava pulp or 50% cassava peel at a rate of 1.5% body weight together with *ad libitum* rice straw and found no significant difference in body weight gain between the treatment groups although beef cattle on cassava peel consumed less DM than other cattle. Nitipot *et al*. (2004) replaced cassava chip by cassava pulp at a rate of 0, 50, and 100% in the concentrates and fed crossbred Holstein Friesian (>87.5% Holstein Friesian) heifers 2% body weight of concentrate plus *ad libitum* rice straw. The results showed that rice straw and total DM intake, eating behavior, fiber digestibility, rumen fermentation end-products, blood metabolite and body weight gain were similar in all treatments. When the data for milk yield and body weight change were combined, it was possible to compare the effect of different rations on the apparent utilization of NE_{LP} intake (Table 5). All cows consumed NE_{LP} therefore the partitioning of energy between milk productions was also similar.

Table 1. Chemical composition, energy values, rumen degradable protein, rumen undegradable protein and degradability of CP of feedstuffs

Chemical composition (%)	Cassava chip	Cassava pulp	Ground corn	Soy bean meal	Rice bran
DM	89.7 ± 0.07	92.6 ± 0.06	92.5 ± 0.15	92.1 ± 0.18	93.0 ± 0.10
CP	2.3 ± 0.05	2.6 ± 0.06	8.8 ± 0.09	48.5 ± 0.03	12.1 ± 0.04
EE	0.3 ± 0.04	0.2 ± 0.04	4.7 ± 0.04	0.9 ± 0.03	19.2 ± 0.02
Ash	8.5 ± 0.09	3.8 ± 0.01	2.5 ± 0.01	6.6 ± 0.08	13.9 ± 0.05
CF	4.6 ± 0.07	6.6 ± 0.04	2.7 ± 0.02	5.9 ± 0.08	14.6 ± 0.09
NDF	19.2 ± 0.09	37.6 ± 0.18	9.7 ± 0.04	15.3 ± 0.12	30.7 ± 0.03
ADF	6.0 ± 0.04	9.8 ± 0.12	3.5 ± 0.04	9.1 ± 0.20	21.7 ± 0.05
ADL	2.2 ± 0.02	3.9 ± 0.04	1.3 ± 0.01	1.3 ± 0.06	9.6 ± 0.19
NFC	69.7 ± 0.11	55.9 ± 0.17	73.4 ± 0.10	27.8 ± 0.15	26.1 ± 0.10
NDIN	0.47 ± 0.01	0.12 ± 0.01	1.01 ± 0.01	1.06 ± 0.04	1.23 ± 0.001
ADIN	0.55 ± 0.02	0.05 ± 0.04	0.79 ± 0.01	0.78 ± 0.03	0.74 ± 0.01
TDN_{1X} (%)[1/]	72.9 + 0.13	69.9 + 0.14	87.8 + 0.14	78.2 + 0.15	72.2 + 0.17
DE_{1X} (Mcal/kgDM)[2/]	3.07 + 0.02	2.96 + 0.02	3.78 + 0.03	3.93 + 0.02	3.16 + 0.03
DE_P (Mcal/kgDM)[3/]	2.83 + 0.02	2.77 + 0.02	3.30 + 0.02	3.55 + 0.02	2.93 + 0.02
ME_P (Mcal/kgDM)[4/]	2.40 + 0.01	2.33 + 0.01	2.89 + 0.01	3.13 + 0.01	2.56 + 0.01
NE_{LP} (Mcal/kgDM)[5/]	1.48 + 0.01	1.44 + 0.01	1.85 + 0.01	2.00 + 0.01	1.65 + 0.01
RDP (g/kgDM)	-	-	53 + 0.6	311 + 0.17	71 + 0.25
RUP (g/kgDM)	-	-	35 + 0.4	175 + 0.09	49 + 0.18
dg of CP	-	-	0.60	0.64	0.59

Mean ± SE; DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; NFC = non fiber carbohydrate = 100 - (%NDF + %CP + %Fat + %Ash); NDIN = neutral detergent insoluble nitrogen; ADIN = acid detergent insoluble nitrogen.

[1/] TDN_{1X} (%) = tdNFC + tdCP + (tdFA × 25.25) + tdNDF – 7)

[2/] DE_{1X} (Mcal/kg) = [(tdNFC/100) × 4.2] + [(tdNDF/100) × 4.2] × [(tdCP/100) × 5.6] + [(FA/100) × 9.4] – 0.3

[3/] DE_P (Mcal/kg) = $\{[(TDN_{1X} - [(0.18 \times TDN_{1X}) - 10.3]) \times \text{Intake}]/TDN_{1X}\} \times DE_{1X}$

[4/] ME_P (Mcal/kg) = $[1.01 \times (DE_p) - 0.45] + [0.0046 \times (EE - 3)]$

[5/] NE_{LP} (Mcal/kg) = $[0.703 \times ME_p] - 0.19$ (Moe and Tyreell, 1972) ($EE \leq 3\%$)

[5/] NE_{LP} (Mcal/kg) = $([0.703 \times ME_p] - 0.19) + [(0.097 \times ME_p)/97] \times [(EE - 30]$ ($EE > 3\%$)

RDP = rumen degradable protein.

RUP = rumen undegradable protein.

Table 2. Formulation of concentrates used in the experiment (kg fresh weight)

Ingredients	35% Cassava pulp	40% Cassava pulp	45% Cassava pulp
Cassava pulp	35	40	45
Ground corn	25.5	20.5	15.5
Soy bean meal	16	16	16
Rice bran	10	10	10
Molasses	10	10	10
Urea	2.5	2.5	2.5
Mineral mix	0.5	0.5	0.5
Vitamin-mineral premix	0.5	0.5	0.5
Total	100	100	100

Mineral mix contains per kg: 120 g Ca; 140 g Na; 32 g P; 20 g S; 15.4 g Mn; 7 g Zn; 2 g Mg; 1 g Fe; 1.25 g Cu; 0.33 g Co; 0.03 g Se; 0.1 g I.

Vitamin-mineral premix contains per kg: 2,000,000 IU Vit. A; 640,000 IU Vit. D_3; 64,000 IU Vit. E; 160 g Ca; 99 g S; 80 g P; 16 g Fe; 16 g Mn; 12 g Zn; 3 g Cu; 0.2 g I; 0.05 g Co; 0.05 g Se.

Table 3. Chemical and nutrient composition of feeds used in the experiment

Chemical composition (%)	Grass silage	35% Cassava pulp	40% Cassava pulp	45% Cassava pulp
DM	92.6 ± 0.15	86.9 ± 0.03	87.9 ± 0.02	87.2 ± 0.01
CP	7.3 ± 0.05	21.7 ± 0.19	21.4 ± 0.09	21.3 ± 0.15
EE	2.50 ± 0.07	3.54 ± 0.04	2.93 ± 0.02	2.40 ± 0.01
Ash	14.4 ± 0.20	6.4 ± 0.18	6.7 ± 0.03	7.0 ± 0.11
CF	36.2 ± 1.00	9.6 ± 0.09	10.8 ± 0.01	11.7 ± 0.17
NDF	53.8 ± 0.17	31.7 ± 0.75	35.7 ± 0.03	42.5 ± 0.03
ADF	34.0 ± 0.51	13.1 ± 0.32	14.6 ± 0.31	13.9 ± 0.01
ADL	5.93 ± 0.11	2.29 ± 0.08	2.37 ± 0.07	2.40 ± 0.08
NDIN	0.72 ± 0.04	1.41 ± 0.01	1.39 ± 0.01	1.29 ± 0.01
ADIN	0.47 ± 0.01	1.21 ± 0.01	1.17 ± 0.01	0.97 ± 0.01
TDN_{1X} (%)	51.5 ± 0.08	74.1 ± 0.09	71.8 ± 0.14	69.2 ± 0.01
DE_P (Mcal/kgDM)	2.40 ± 0.01	3.09 ± 0.01	3.03 ± 0.01	2.97 ± 0.01
ME_P (Mcal/kgDM)	1.97 ± 0.01	2.67 ± 0.01	2.61 ± 0.01	2.54 ± 0.01
NE_{LP} (Mcal/kgDM)	1.19 ± 0.01	1.69 ± 0.01	1.64 ± 0.01	1.60 ± 0.01
dg of CP	0.726	0.689	0.681	0.672

Mean ± SE; DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADL = acid detergent lignin; NFC = non fiber carbohydrate = 100 - (%NDF + %CP + %Fat + %Ash); NDIN = neutral detergent insoluble nitrogen; ADIN = acid detergent insoluble nitrogen; TDN_{1X} = total digestible nutrient at maintenance level; DE_P = digestible energy at production level; ME_P = metabolizable energy at production level; NE_{LP} = net energy for lactation at production level; *dg* = degradability.

All groups of cows had considerable supply of NE_{LP} but the milk yields were lower than would have been expected from NE_{LP} intakes. The respective intake of 21.7, 22.0, and 21.7 Mcal daily by cows on 35%, 40%, and 45% cassava pulp, in theory, should have been able to produce approximately 21.9, 19.8, and 20.5 kg milk/day respectively. A lower milk yield than that would be expected from NE_{LP} available which can be attributed to the probable underestimates of NE_{LM} for dairy cows in the tropics. Since the dairy cows in the tropics were fed lower quality feeds than those in the United States, the use of the equation suggested by the NRC (2001) might be inappropriate. AAC (1990) recommended that dairy cattle consuming feeds containing energy lower than 10 MJ ME/kg DM (2.39 Mcal ME/kgDM) needed more energy for maintenance. The present study used a net energy maintenance

Table 4. Mean values for DM, CP, and NE_{LP} consumption, and mean performance values of the experimental cows

	35% Cassava pulp	40% Cassava pulp	45% Cassava pulp	SEM	Pr > F
DM intake					
Concentrate (kg/cow/d)	7.0	7.0	7.0	-	-
Grass silage (kg/cow/d)	8.3	8.8	8.8	0.52	0.749
Total	15.3	15.8	15.8	1.09	0.703
CP intake					
Concentrate (g/cow/d)	1,519	1,498	1,491	-	-
Grass silage (g/cow/d)	606	642	642	38.46	0.751
Total	2,125	2,140	2,133	38.46	0.734
NE_{LP} intake					
Concentrate (Mcal/cow/d)	11.8	11.5	11.2	-	-
Grass silage (Mcal/cow/d)	9.9	10.5	10.5	0.60	0.751
Total	21.7	22.0	21.7	0.60	0.918
Milk yield (kg/cow/d)	14.2	14.1	14.8	0.71	0.742
3.5% FCM (kg/cow/d)	13.8	14.1	14.8	0.60	0.556
Fat yield (kg/cow/d)	473	491	517	23.58	0.427
Protein yield (kg/cow/d)	393	400	398	16.22	0.963
Lactose yield (kg/cow/d)	626	671	650	3.39	0.634
SNF yield (kg/cow/d)	1,152	1,158	1,177	54.10	0.927
Total solid yield (kg/cow/d)	1,622	1,607	1,690	73.33	0.656
% Fat	3.33	3.48	3.49	0.10	0.484
% Protein	2.77	2.84	2.69	0.05	0.227
% Lactose	4.41	4.76	4.39	0.07	0.115
% SNF	8.11	8.21	7.95	0.09	0.174
% Total solid	11.42	11.40	11.42	0.17	0.992
Body weight (kg)					
Pre-experiment	430	431	448	56.5	0.736
Post-experiment	432	446	455	20.5	0.726
Live weight change (g/d)	+ 36[c]	+ 232[a]	+ 125[b]	9.7	0.013

[a-c] values with no common superscript differ significantly (p<0.05) when tested with Duncan's Multiple Range Test.

SEM = standard error of the mean.

value of 0.08 Mcal/kg $BW^{0.75}$ for predicting NE_{LM}. If the hypothesis by AAC (1990) is true, with the assumption that the average net energy values of milk and body weight change are unaffected by the quality of feeds as in case of NE_{LM}, the average net energy maintenance value of 0.123 Mcal/kg $BW^{0.75}$ should be used in this study. This is approximately 54% higher than the NRC (2001) recommendation. Suksombat and Junpanichcharoen (2005) suggested that, in the tropics, the average net energy maintenance value of 0.106 Mcal/kg $BW^{0.75}$ would be more appropriate than the value of 0.08 Mcal/kg $BW^{0.75}$ recommended by NRC (2001). Similarly, the work of Suksombat and Mernkrathoke (2005), the calculated average net energy

Table 5. Estimates of the distribution of net energy intake

	35% Cassava pulp	40% Cassava pulp	45% Cassava pulp	SEM	Pr > F
NE_{LP} intake (Mcal/d)	21.7	22.0	21.7	0.56	0.730
NE_{LM} (Mcal/d)	7.6	7.7	7.8	0.18	0.284
NE_{LG} (Mcal/d)	0.2[c]	1.1[a]	0.7[b]	0.07	0.014
NE_{LL} (Mcal/d)	9.0	9.4	9.5	0.89	0.211
NE_{LR} (Mcal/d)	16.8	18.2	18.2	1.21	0.344
Balance	+ 4.9	+ 3.8	+ 3.5	0.68	0.384

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 × $LW^{0.75}$.

NE_{LG} : net energy requirement for gain = reserve energy × (0.64/0.75)
reserve energy = see NRC (2001)

NE_{LL} : net energy requirement for lactation = milk yield (kg/d) × (0.0929 × %fat + 0.0547 × %CP + 0.0395 × %Lactose).

NE_{LR} : net energy retention.

SEM = standard error of the mean.

Table 6. The estimated supply of rumen degradable protein and rumen undegradable protein

	35% Cassava pulp	40% Cassava pulp	45% Cassava pulp	SEM	Pr > F
RDP_{req} intake (g/d)	1,436	1,388	1,402	38	0.783
RDP_{sup} (g/d)	1,381	1,370	1,365	4	0.875
Deficit/surplus	-55	-18	-37	39	0.529
RUP_{req} (g/d)	857	825	876	75	0.830
RUP_{sup} (g/d)	774[b]	770[a]	768[a]	2	0.0001
Deficit/surplus	-113	-55	-108	75	0.829

Means with different superscripts within rows significantly differed.

RDP_{req} : rumen degradable protein requirement = 0.15294 × TDN actual

RDP_{req} : 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 Total - RDP_{sup}

SEM = standard error of the mean.

maintenance value was 0.083 Mcal/kg $BW^{0.75}$ which was 3.7% higher than that of NRC (2001) recommendation. Before a conclusion can be reached, further research is needed.

Using the protein degradability values of each feed (determined by nylon bag technique), the estimated supplies of RDP and RUP to the cows was calculated (Table 6). All cows consumed similar RDP. Cows on all treatments received adequate RDP, however, cows on 35% and 45% cassava pulp diets received inadequate RUP. Digestible RUP 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 may be stored as fat, then milk production might be less than would have been expected from energy intake. Therefore, feeds containing a high bypass protein such as cotton seed meal are needed to increase RUP supply.

The present study indicated that cassava pulp had a moderate energy value and thus 45% cassava pulp can be used in the concentrate for lactating dairy cows.

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