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Effect of cassava (*Manihot esculenta*) root meal supplemented with Nile Perch (*Lates niloticus*) fish waste on the rumen environment

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Abstract. The supplementary effect of cassava (*Manihot esculenta*) root meal (CRM) and Nile Perch (*Lates niloticus*) fish waste (FW) on the rumen environment was compared to that hominy meal (HM) and cotton seed cake (CSC). The feed's degradability characteristics and chemical contents, rumen pH and rumen ammonia nitrogen (NH_3-N) levels in cows fed on four ration combinations (HM + CSC, CRM +CSC; HM + FW and CRM +FW) denoted as T_1, T_2, T_3, T_4, respectively) were determined. Results showed that DM degradability at 48h for CRM was higher ($P<0.05$) than that of HM (920 vs 835 g/kg). HM had higher ($P<0.05$) CP content than CRM (946 vs 837 g/kg) respectively. Both DM and CP contents of CSC were higher ($P< 0.05$) than those of FW (739 and 887 vs 367 and 598 g/kg) respectively. The degradability of DM for the TR_1 and TR_2 rations was higher ($P< 0.05$) than that of TR_3 and TR_4 (801 and 799 vs 727 and 616 g/kg DM respectively. TR_2 had higher ($P< 0.05$) rates of DM degradability than the rest of the rations. The ruminal pH and NH_3-N values differed ($P< 0.05$) between treatments. Treatments containing FW (TR_3 and TR_4) had higher ($P< 0.05$) NH_3-N than those containing CSC (TR_1 and TR_2) (284.7 and 203.7 vs 135.8,and 183.9 mg/l). It is concluded that CRM when fed in combination with FW gave higher DMD values and provided a better fermentation environment than HM and CSC. It is further concluded that CRM and FW could be good substitutes for HM and CSC as sources of energy and nitrogen for dairy cattle and other ruminant animals.

Introduction

Poor quality hays are low in energy and protein content, which cannot meet the nutrient requirement of cattle in terms of absorbable amino acids and microbial protein (Preston and Leng 1987; Smith *et al*., 1991, Shem *et al*., 1995; Kimambo *et al*., 1999). Rations balanced for energy and protein are thus necessary to ensure maximum dry matter intake and degradability of and for the creation of optimal rumen environment. According Pham Kim Cuong *et al*. (2001), the rate and extent of fermentation of cell wall carbohydrates in the rumen and their absorption is the major goal of any economic ruminant feeding regime. Fresh cassava root is low in dry matter but rich in energy due to its high content of starch and its high amylopectin content. This makes it a more suitable source of energy for ruminants than maize (Kanjanapruthipong *et al*., 2001) maize. On the other hand, FW are an excellent source of rumen undegradable protein (RUDP) (Thonney and Hogue, 1986) compared to cotton seed cake, which is good source of rumen degradable protein (RDP). Supplementary rations containing FW have been reported to improve total rumen digestible organic matter (Pham Kim Cuong *et al*., 2001). Conventional energy and supplement feeds have become very expensive and beyond the purchasing power

of most small-scale livestock producers in Tanzania and have limited supply due to the expanding local demand and from the local and external markets,. That coupled by the huge competition for cereals from human beings necessitates the search for alternative locally available feed resources including cassava root meal (CRM) and Nile fish wastes (FW).

The utilization of CRM and FW livestock feeding is well documented (Pham Kim Cuong *et al.*, 2001; Sammart *et al.*, 2000). They are also abundant and locally available in Tanzania (Katakweba, 2002) and have huge potential to replace cereal and oil seed by-products in livestock feeds in Tanzania. However, the choice of any supplement usually will depend on its availability, cost and its nutritive value (Shem *et al.*, 2003).

The major objective of this study was therefore, to evaluate the nutritive value of CRM, specifically its effects on changes in the rumen environment when supplemented with Nile perch fish wastes.

Materials and Methods

Feeds. The experimental animals were fed on a basal diet of *Chloris gayana* grass hay chopped to approximately 2-3 cm length. Supplemental rations contained CRM, HM, FW, CSC and minerals of different proportions. Fresh cassava was purchased from farmers in villages in Morogoro rural district while FW was obtained from the numerous fish processing factories around Mwanza City on the shores of Lake Victoria. The unpeeled fresh cassava roots were washed with clean water to remove the soil, chopped by hand into small slices and sun dried for three days to reduce HCN from 863 to 90.5 mg/kg DM (Bui Van Chinh and Le Viet Ly, 2001). It was then packed, weighed and stored under moisture free conditions. Hominy meal, cotton seed cake and minerals were purchased from feed stores in Morogoro town.

Treatments and experimental design. The four treatment rations used in the experiment are as shown in Table 1. Treatment 1 (TR_1) was composed of hay, CRM and HM. Treatment 2 (TR_2) contained hay, CSC and CRM; treatment 3 (TR_3) included hay, FW and HM and treatment 4 (TR_4) contained hay, FW and CRM in a 4 x 4 (four animals x four treatments) Latin square design experiment using fistulated Friesian–Zebu crossbreed cows (314 ± 25kg liveweight) in four periods.

Experimental animals and their management. Prior to commencement of the experiment the animals were dewormed using Levamisole injectable solution (1ml/10kg live weight) (Hoonspraten Ltd Belgium) and supplied with multivitamins at the rate of (1ml/10kg live weight) (Hoonspraten Ltd Belgium). To control ectoparasites, a pour on acaricide (pyrethrins) (Coopers Ltd, Nairobi Kenya) at the rate of (1ml/20kg live weight) was used. The cows were put in individual pens and fed on poor quality hay *ad libitum* and had water.

Table 1: Feed proportions in the treatment rations (kg DM).

Ingredients	Treatments			
	TR_1	TR_2	TR_3	TR_4
Cotton seed cake (CSC)	315	480	-	-
Fish wastes (FW)	-	-	305	465
Hominy meal (HM)	665	-	675	-
Cassava root meal (CRM)	-	500	-	515
Minerals	20	20	20	20
Total	1000	1000	1000	1000

Before collection of data, the rumen environment was stabilized by feeding the animals 3 kg daily of a concentrate mixture composed of 0.3, 0.3, 0.2 and 0.2 parts CSC, FW, CRM and HM respectively and minerals at the rate of 2% of total ration. During the actual experiment, the cows were fed treatment rations at the rate of 11.6-g/kg body weight once every morning.

Data collection of rumen ecosystem. Samples for the rumen pH and NH_3-N were collected before feeding at 07h and subsequently at interval of 2 hours for 24 hours. Prior to that all animals were acclimatized to the treatment rations for 10 days. Samples were collected every 11th day of the experiment for each treatment ration. Rumen liquor samples were obtained by squeezing ruminal contents collected 15 cm beneath the fistula opening. The fluid was then strained using surgical gauze into four 100-ml plastic jars; one for each cow and the rumen pH recorded immediately using a portable electronic pH meter. After the pH reading, three drops of concentrated sulphuric acid were added to the samples to avoid N losses. They were then ice parked in a cool box and immediately transported to the laboratory and stored at -200 ^{0}C until they were analyzed for NH_3-N after being centrifuged at 3000 rpm for 15 minutes. NH_3-N content was determined using the Kjeltec distillation unit using a strong alkali (NaOH) instead of a weaker Magnesium oxide (MgO) (A.O.A.C., 1990; Kimambo *et al*., 1999).

Rumen degradability study. Dry matter degradability (DMD) of the individual feeds and treatment rations were determined *in Sacco* (Ørskov *et al*., 1980). Two-labeled nylon bags of size 40 to 50 mm containing 2 g of each sample were labeled and incubated in four animals at different time intervals of 6, 12, 24, 48, 72 and 96h for feed ingredients and up to 72 h for treatment rations. For each incubation time, the bags were removed from the rumen, washed in running tap water until the water was clear. The bags were then run through a stomacher (Model 400 Lab Blender) to minimize microbial contamination and immediately stored in a deep freezer at a temperature of between –15 ^{0}C and –20 ^{0}C to stop further microbial activity. After thawing, all samples were filtered on labelled N-free filter papers and dried at 100 ^{0}C for 24 hours and their residual weights calculated. Samples were then digested and distilled for the determination of nitrogen using the Kjeltec distillation unit (A.O.A.C., 1990).

The percentage of DM degraded (P) at time t, was determined according to the mathematical model $P = a + b (1-e^{-ct})$ (McDonald, 1981). Where P is proportion of the DM degraded at time t, a is the zero time intercept (of degradation curve at time zero), b is the potentially rumen degradable portion, c (h^{-1}) is the rate constant at which b is degraded, a + b is the potential rumen degradability (asymptote). All the degradability characteristics and those at 48-hours were calculated from raw data using the NAWAY computer program developed by the Rowett Research Institute, Aberdeen, U.K (Shem *et al*., 1995). The feed's metabolizable energy (ME) was calculated according to the following formulae:

ME (MJ/kg DM) = 0.15 or 0.16 DOMD % (MAFF, 1975)

Where DOMD = 0.98 DMD %-4.8. Where DOMD %= Dry organic matter digestible and DMD % (g/kg DM) = in this case was the 48h degradability. The coefficient was varied according to the class of feed; 0.15 was used for hay and 0.16 for supplementary rations also according to MAFF (1975).

Chemical analysis. The feed ingredients (CSC, FW, HM, CRM and hay), treatment rations and residual samples were analyzed for their chemical contents (DM, Ash and CF) using the proximate analysis (A.O.A.C, 1990). Crude protein (CP) was determined using a semi- automatic Kjeldatech method and ether extract (EE) was determined by using Soxhlet extraction technique. Neutral detergent fiber (NDF) and acid detergent fiber (ADF)

contents were also analyzed according to the method of Van Soest *et al.* (1991).

Statistical analysis. All the data collected were analyzed using the General Linear Model Procedure (GLMP) and means were compared using the LSD method (SAS, 1990).

Results

The chemical composition of the feed ingredients namely CSC, FW, CRM, HM and hay are presented in Table 2. FW collected in the dry season had higher (P<0.05) DM and EE than that during the rainy season but all had higher CP, EE, DM and Ash contents than CSC. In the same table, CRM had lower (P<0.05) CF, EE CP contents than hominy meal (HM) and hay had the lowest CP and highest NDF and ADF of all the feed ingredients.

Chemical compositions of the treatment rations are also summarized in Table 2. The average (DM) contents of the treatment rations were above 960g/kg DM and their CP was almost similar in all rations (201-206 g/kg DM). Crude fat (EE) was highest in TR_3 (94 g/kg DM) and lowest in TR_2 (26 g/kg DM). Ash content was highest in TR_4 (240 g/kg DM) and lowest in TR_1 (69 g/kg DM). Energy content was highest in rations containing CSC (TR_1 and TR_2) and lowest in rations with FW (TR_3 and TR4).

Rumen pH values were not (P>0.05) different between treatments (Table 3). However, NH_3-N levels were (P<0.05) different (TR_3 (283.7 mg/l), TR_4 (203.7 mg/l), TR_2 (183.9mg/l) and TR_1 (135.8 mg/l). There was a rapid surge in NH_3-N between 1 and 2 hr after feeding in all rations followed by a rapid decline after the 3rd hour (Figure 1). NH_3-N levels evened out but were higher for treatments containing FW.

The degradability characteristics and ME data for the feed ingredients and the feed rations are shown in Tables 4 and 5 respectively. Degradability characteristics were higher (P<0.05) in CSC than in FW except for **c** (h^{-1}) value (0.069 h^{-1}), which was higher in FW than in CSC (0.046 h^{-1}). Energy content (ME) was also higher (P<0.05) in CSC (10.8 MJ/kg DM) than in FW (5.5 MJ/kg DM). The degradation rate constant (**c**) was higher

Table 2: Chemical composition of experimental feeds and treatment rations (g/kg DM).

Feed type	DM	CP	EE	ASH	NDF	CF	ADF	Ca	P	K	Na	Mg	ME
Fish wastes													
Rainy season	961	396	151	347				98	40.0	4.8	5.4	2.0	
Dry seasons	985	397	218	344				136	71.5	4.5	6.4	2.11	
Cassava root													
Whole CRM	921	43	8	51				0.9	4.5	2.9	4.1	3.7	
Other experimental feeds													
Cotton seed	958	373	75	63	51		347						
Hominy meal	964	139	85	46	630		80						
Hay	967	42	5	89	794		554	5.2	1.3	12.3	3.2	1.5	
Treatment rations													
TR_1	969	201	76	69	449	113		4.6	6.4	12.9	4.3	3.6	13
TR_2	967	202	26	74	426	116		6.3	2.6	17.0	6.4	3.1	12
TR_3	973	203	94	167	470	51		44.2	17.8	9.3	5.4	3.0	11
TR_4	972	206	58	240	601	63		61.9	28.9	11.0	4.7	1.8	9

DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = crude fiber, SD =sun dried NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ASH = Ash, ME = Metabolizable energy.

Table 3: Rumen NH_3-N (mg/l) and pH from fistulated cows fed on treatment rations.

Parameter	Treatments				SEM	Pr > F	Significance
	TR_1	TR_2	TR_3	TR_4			
pH	6.4[a]	6.2[a]	6.1[a]	6.3a	0.099	0.0001	***
NH_3-N	135.8[d]	183.9[c]	283.7[a]	203.7[b]	24.81	0.0001	***

*** = Highly significant at P <0.0001.
Super script [a, b, c, d,]; means within each row bearing same letter are not. significantly different at P<0.05.

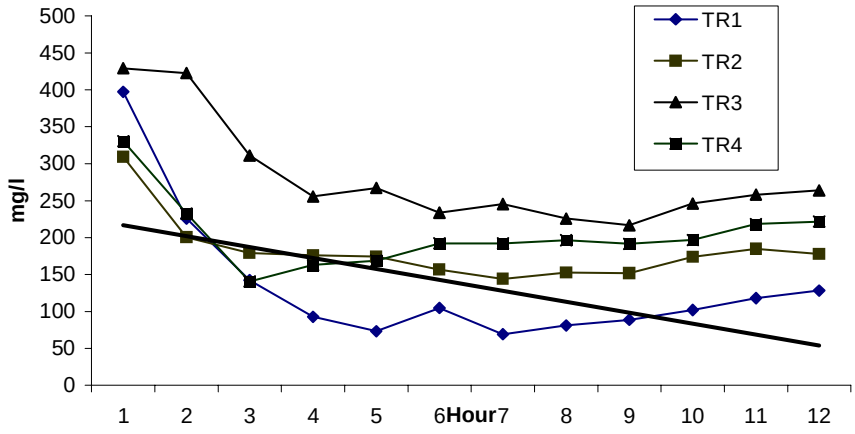

Figure 1: Diunal change in rumen NH_3-N according to treatment.

Table 4: DM degradation characteristics a, b, (g/kg DM), c (h^{-1}) 48h and metabolizable energy (ME) (MJ/kg DM) of the experimental feeds.

Feed ingredient	a	b	a + b	48h	c	ME
FW	116[e]	297[c]	413[c]	397[d]	0.069[b]	5·5[d]
CSC	285[c]	537[b]	822[b]	739[c]	0.046[b]	10.8[c]
HM	356[b]	622[a]	978[a]	835[b]	0.031[b]	12.3[b]
CRM	603[a]	322[c]	925[a]	920[a]	0.153[a]	13.7[a]
Hay	152[d]	234[d]	386[c]	362[d]	0.058[b]	4.9[d]
SEM	0.770	1.815	1.619	1.435	0.024	0.328
Pr > F	0.0001	0.0001	0.0001	0.0001	0.0378	0.0001
Significance	***	***	***	***	*	***

ME= 0.16*DOMD% and DOMD%= 0.98 DMD%-4.8 and DMD%= 48h DM.
* = Significant at P< 0.05.
*** = Highly significant at P <0.0001.
Super script [a, b, c, d,]; means within each column bearing same letter are not significantly different at P<0.05.

Table 5: DM degradation characteristics (g/kg DM), and Metabolizable energy (ME) (MJ/kg DM) of the treatment rations.

Feed rations	a	b	a + b	48h	c h^{-1}	ME	DMD %	OMD %
TR_1	328[b]	656[a]	983[a]	807[a]	0.024[cb]	11.9[a]	684	736
TR_2	237[c]	566[b]	803[c]	791[ba]	0.089[a]	11.7[a]	733	793
TR_3	333[b]	586[b]	920[b]	727[b]	0.019[c]	10.6[b]	639	77
TR_4	418[a]	268[c]	682[d]	616[c]	0.034[b]	8.9[c]	719	840
SEM	0.473	2.478	2.209	2.021	0.005	0.209		
Pr > F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		
Significance	***	***	***	***	***	***		

ME= 0.16*DOMD% and DOMD%= 0.98 DMD%-4.8 and DMD%= 48h DM.
*** = Highly significant at P <0.0001.
%= Invitro: 48h Dry matter digestibility (DMD) and Organic matter digestibility (OMD).
Super script [a, b, c, d,]; means within each column bearing same letter are not significantly different at P<0.05.

(P<0.05) for TR_2 (0.089h^{-1}) and lowest in TR_3 (0.019 h^{-1}) and the insoluble but potentially degradable fraction (**b**), 48h DM degradability and potential degradability (**a+b**) were lowest for TR_4. The latter ration had the lowest (P<0.05) metabolizable energy (ME) (8.91 MJ/kg DM) and TR_2 the highest (11.65 MJ/kg DM). Protein source seem to have had influence on the ration's degradability characteristics and ME content as treatments containing FW (TR_3 and TR_4) had higher (P<0.05) degradability characteristic **a** compared to TR_1 and TR_2. Energy source also had influence on potential degradability (**a**+**b**). Treatment rations containing HM showed higher (P<0.05) potential degradability values than those containing CRM.

Discussion

The pH values obtained in this study were within recommended range for ruminants feeding on low quality roughage (Klusmeyer *et al*., 1990; Kimambo *et al*., 1999). Inclusion of CRM adds to the rapidly fermentable sugars, compounds that are known to lower rumen pH (Sommart *et al*., 2000). However, the inclusion of CRM in TR_2 and TR_4 did not change the rumen pH values probably due to high production of volatile fatty acids (Sommart *et al*., 2000). The latter authors reported that even at an inclusion rate of 54% CRM failed to lower or affect rumen pH and function respectively. At around pH 6 rumen functions are not likely to be severely interfered (Klusmeyer *et al*., 1990). Like in the latter author's study, rumen pH values did not deviate from neutrality.

The relatively high rumen NH_3-N values observed for CRM containing diets were in contrast with the findings by Pham King Cuong *et al.* (2001) who reported lower values from CRM fed cattle. This was probably due to the partial degradability of FW in the rumen and the high requirement of rumen NH_3-N for diets with high CP content (Odle and Schaefes, 1986). When CRM replaced HM as energy substrate in TR_2, the levels of rumen NH_3-N were significantly raised. This probably arose from the fact that there was an increased energy supply in the rumen activating the rumen microbes and thus the degradation of CSC at a faster rate.

Cotton seed cake had high DM degradation rates than FW; an indication of the former feed's higher degradability. Possible explanations for the difference in DM degradability of FW and CSC include, differences in solubility, chemical characteristics and presence of cross-linked disulphide bonds or cyclical structures of the protein (Preston and Leng, 1987; Pham Kim Cuong *et al*., 2001). Khan *et al*. (1998), Kimambo *et al*. (1999), Pham Kim Cuong *et*

al. (2001) also reported lower DM and/or N disappearance in the rumen from protein sources of animal origin than those of vegetable origin except casein.

Therdchai and Mikled (2001) reported over 94 % of CRM to be degraded in the rumen, while Ørskov (1986) and Therdchai (1987) reported over 40% of corn carbohydrates to escape rumen degradation. Further more Smith *et al*. (1991) and Kanjanapruthipong *et al*. (2001) observed carbohydrates in cassava to be degraded twice or thrice faster than those of corn. Supriyati *et al*. (1995) and Barkrie *et al*. (1997) reported that multiplication of rumen microbes could be significantly increased following inclusion of CRM as an energy substrate. Through this method, Barkrie *et al*. (1997) were able to produce "Cassapro" (fermented cassava roots) via solid-state fermentation using CRM and *Aspergilus niger*. Cassapro is currently a popular ingredient in ruminants' diets in Indonesia (Supriyati *et al*., 1995; Barkrie *et al*., 1997).

Treatments containing CSC were rich in ME and had higher DM degradability than those containing FW due to the good interaction between protein and energy at the rumen level. The main differences in DM degradation between treatment rations with FW compared to that of CSC was due to the by pass protein of FW in TR_3 and TR_4 (Barlow and Windsor, 1984).

Conclusion

The high DM degradability of the feed ingredients and treatment rations and their improvement on the rumen ecosystem results (pH and NH3-N) suggest that supplementary feeding of CRM and FW to ruminants instead of CSC and HM is ideal under practical feeding conditions.

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