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Substitution of hominy meal with cassava root meal as a source of energy for growing dairy heifers

Katakweba A.A.S., Shem M.N., Aboud A.A.O., Sarwatt S.V., Lekule F.P. and Mutayoba S.
Department of Animal Science and Production, Sokoine University of Agriculture,
P.O. Box 3004, Morogoro, Tanzania

Abstract. An experiment was carried out to evaluate the effect of cassava (*Manihot esculenta*) root meal (CRM) and fish wastes (FW) on the growth of dairy heifers in four rations. The rations were TR_1 (66.5 % HM and 31.5 % CSC) TR_2 (50 % CRM and 48 % CSC) TR_3 (67.5 % HM and 30.5% FW) and TR_4 (51.5 % CRM and 46.5 % FW). Twenty Ayrshire heifers (average weight 145±8 kg) were randomly allocated to the four rations in a completely randomized block design. Data was collected on dry matter intake (DMI), weight gain, glucose, Ca, P and protein blood levels. No difference (P>0.05) in weight gain was observed between heifers on TR_1 and TR_3. Heifers on TR_2 showed faster growth rates (P< 0.05) than those in other treatments (i.e. 620 versus 490, 460 and 410 g for TR_1, TR_3 and TR_4 respectively). Correspondingly heifers on TR_2 had superior (P< 0.05) feed efficiency (0.116) followed in a descending order by TR_1, TR_3 and TR_4 (0.097, 0.092 and 0.085 kg gain / kg feed. Heifers receiving diets containing FW had higher (P<0.05) Ca and P than those on CSC. Blood glucose and plasma protein were higher (P<0.05) in heifers receiving TR_1 (97.07g/l and 3.3 mmol/l) than those on TR_2 (94.86 g/l and 3.0 mmol/l). It is concluded that CRM could be used alone as energy source when combined with protein rich feeds like CSC and FW.

Introduction

In Tanzania, poor pre-and post-weaning performance in dairy heifers has been cited as one of the major reasons for delayed puberty and slow herd growth (Kurwijila, 1976). The overall effects of underfeeding are high pre-weaning mortalities (8-20 %) and poor post-weaning growth rates (Kifaro *et al*., 1987) and thus longer rearing periods before weaning and age at first breeding (Kimambo *et al*., 1990; Kasongo *et al*., 1995; Mohamed, 1998). Supplementary feeding of heifers with energy and protein rich feeds is therefore necessary to avoid such situations.

The common energy and protein supplements for growing ruminants on medium and large scale dairy farms in Tanzania are maize bran/hominy meal, cotton and sunflower seed cakes and forage legumes (Lekule, 1990). However, supplementary feeding of livestock is rarely done in most smallholder dairy farms as the price of concentrates is high and often beyond the purchasing power of the farmers (Shem, 1993). A good example is the unavailability of cotton seed cake due its higher export markets in neighbouring countries. Another constraining factor is the low production and competition for cereals from human beings and monogastric animals. This has led to vigorous efforts to look for other alternative feeds for ruminants including cassava root meal (CRM) and fish wastes (FW) (Israel, 1986; Katakweba, 2002).

Cassava root meal is an excellent energy source for livestock (Wanapat, 1999; Sommart *et al*., 2000; Kanjanapruthipong *et al*., 2001). It is however, low in dry matter, protein, fat and minerals and high in amylopectin containing starch (Lekule, 1990). It can completely replace cereals in pig rations

(Lekule, 1990, Israel (1992) and provide fermentable non-fiber carbohydrates for efficient rumen microbial growth (Kanjanapruthipong *et al*., 2001).

Research in Tanzania shows that CRM could replace 50% of maize in lactating dairy cattle rations without decreasing milk production and at much lower production cost per litre of milk (Shem *et al.*, 2003) especially when fed in combination with cotton seed cake (CSC) and other protein feed including those of animal origin. Protein of animal origin like fishmeal and especially fish wastes (FW) are abundant from the fish processing industries around Lake Victoria but are expensive and often are of inconsistent quality and supply (Katakweba, 2002). This state of affairs has greatly contributed to its underutilization in livestock feeding.

Although research in other countries show that FW use in livestock rations is economically viable (Zinn and DePeters, 1991; McDonald *et al*., 1998), there is no much data on their use in practical livestock feeds in Tanzania unlike on sardines in poultry rations (Mbamba, 2000). The few existing reports on Nile perch FW use are based on laboratory evaluations (Ngate, 1997) or on the use of marine FW in non-ruminant feeding trials (Mohamed, 1998; Mbamba, 2000). The latter author reported positive growth rates and high feed conversion efficiency in broiler chicken fed on ration containing marine FW.

This study was therefore, carried out with the general objective of assessing the substitution effect of cassava root meal for hominy meal and cotton seed cake with Nile perch FW, respectively, on the growth performance of growing dairy heifers.

Materials and Methods

Study location. The experiment was carried out at Magadu dairy farm, Sokoine University of Agriculture (SUA) in Morogoro, Tanzania. Morogoro lies about 550m above sea level and experiences a hot climate throughout most of the year. The average humidity is about 78 % and the temperature ranges between 20 ^{0}C and 35 ^{0}C.

Experimental animals and their management. A total of 20 Ayrshire heifers with an average liveweight of 145±8 kg were used in the experiment. The animals were housed in individual pens and allowed free access to drinking water. They were de-wormed monthly using Levamisole (Hoonspraten Ltd Belgium) injectable solutions (1ml/10 kg liveweight). External parasites were controlled using a pour on acaricide (Pyrethrins) (Coopers Ltd., Nairobi Kenya) at a rate of 1ml/20 kg live weight every 3 weeks. The animals were also fed multivitamins (Hoonspraten Ltd Belgium) at 1ml/10 kg live weight at also every 3 weeks also.

Feeds and feeding. All the animals were fed on a basal diet of hay dominated by *Brachiaria brizantha* supplemented with CRM and HM and FW or CSC as energy and protein sources respectively (Table 1). Fresh cassava was purchased directly from farmers in villages in Morogoro rural district while and FW were obtained from the numerous fish processing factories around Mwanza city on the shores of Lake Victoria. The unpeeled roots were washed with clean water, 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.

The treatment rations were: TR_1 (hay, CSC and HM), TR_2 (hay, CSC and CRM), TR_3 (hay, FW and HM) and TR_4 (hay, FW and CRM). The rations were balanced for energy, protein and other nutrients before being fed to the heifers. The experiment was run for a total of 81 days including a 21-day preliminary period to acclimatize the animals to the treatments and 60 days of data collection. The rations were offered separately and in equal amounts

Table 1: Ingredient composition of 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

in the morning (0800 h) and afternoon (1500 h) at the rate of 11.6-g/kg-body weight. Hay and water were fed free choice.

Chemical analysis. Chemical content of the feed ingredients, treatment rations and hay were determined according to the A.O.A.C, (1990) methods. Sun dried FW samples were collected in the dry and wet seasons to establish if there were any seasonal differences in their chemical content.

Samples were fractionated into dry matter (DM) Ash, and crude fibre (CF) and crude protein. Crude protein was determined using a semi-automatic Kjeldatech method (N x 6.25) and ether extract (EE) the soxhlet extraction technique. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to the method of Van Soest (1991). Minerals were analyzed by atomic absorption spectroscopy (AAS) using AAS UNICUM spectrophotometer model 919 and were read at wavelengths of 422.5 for Ca, 884 for P and 285 for Mg. Na and K were determined using the flame photometer technique.

Dry matter and body weight measurements. The dry matter intakes (DMI) were recorded daily and adjusted fortnightly to accommodate changes in bodyweight and then averaged for each heifer at the end of the experiment. Initial and final weights were recorded using a weighbridge for three consecutive days before and at the end of the experiment and at an interval of 14 days in between at 0600 h – 0700 before the morning feed. The data was summarized at the end of the experiment and the average daily gain (ADG) calculated for each heifer.

Blood parameters. Blood samples were collected weekly from all the animals and analyzed for plasma Ca, P, glucose and protein. Samples for glucose analysis were collected into vaccutainer tubes containing sodium fluoride (sodium fluoride acted both as an anticoagulant and as a preservative for glucose). The samples were centrifuged at 2000 rpm for 10 minutes and the clear plasma siphoned into labeled tubes, then frozen at -15 ^{0}C-20 ^{0}C to avoid glycolysis (Kaneko, (1989).

Blood samples for total protein; phosphorus and calcium determinations were collected in heparin containing vaccutainer tubes and handled in a similar manner as those for glucose. Analysis for Ca and P were done using a spectrophotometer (model Cecil C 2041 2000, Cecil instruments Limited, UK). Total plasma protein was determined using RANDOX reagent kit from Randox laboratories, UK (1991). Plasma glucose was determined using RANDOX reagent kit from Randox laboratories, UK (1995) and read at wavelengths of 574 nm for Ca, 420 nm for P, 540 nm for total proteins and 540 nm for glucose.

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

Chemical composition. The chemical composition of the supplement feeds and hay are presented in Table 2. Fish wastes collected during dry season had higher EE, DM and mineral contents than that those collected during the rainy season. Both FW had higher nutritive value than CSC. Hominy meal was superior to CRM in EE, CP and CF. Hay contained the lowest CP and high amounts of NDF and ADF.

The chemical compositions of the treatment rations are also summarized in Table 2. Average DM content of the treatment rations was above 960g/kg DM and the CP ranged from 201-206 g/kg DM in TR_1 to TR_4 respectively. Crude fat (EE) was highest in TR_3 (94 g/kg DM) and lowest in TR_2 (26 g/kg DM) and the 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 containing FW (TR_3 and TR_4). The latter also had higher Ca and P contents than TR_1 and TR_2.

Growth performance There were no differences (P>0.05) in live weight gain between treatments (Table 3). The average daily gain (ADG) between rations was highest (P<0.05) in animals on TR_2 (620 g/day) and lowest in those on TR_4 (410 g/day). Differences (P<0.05) were also observed between treatment rations in terms of feed conversion efficiency (FCE) with TR_2 having the highest (0.116 g/kg) and TR_4 the lowest (0.085 g/kg). The combination of CRM and CSC showed higher (P<0.05) FCE than when CSC was fed in combination with HM or FW combined with both energy sources.

Total DMI. LS means for DMI in Table 3 show significant differences (P<0.05) between rations with animals on TR_2 having higher values followed by TR_1, TR_3, and TR_4 with average intakes of 5.47, 5.11, 4.98 and 4.89 kg/day respectively. Source of protein or energy supplement had effect (P<0.05) on DMI. Heifers on FW containing rations had lower (P<0.05) DMI than those on CSC. Cassava root meal in combination with CSC gave higher DMI (P<0.05) than when it was combined with FW.

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

Feed type	DM	CP	EE	Ash	CF	NDF	ADF	ME (MJ/ kgDM)
Fish wastes								
Rainy season FW (SD)	961	396	151	347				
Dry seasons FW (SD)	985	397	218	344				
Cassava root meal								
Whole CRM	921	43	8	51				
Other experimental feeds								
Cotton seed cake	958	373	75	63		51	347	
Hominy meal	964	139	85	46		630	80	
Hay (*Brachiaria brizantha*) *	967	42	5	89		794	554	
TR_1	969	201	76	69	113	449		13
TR_2	967	202	26	74	116	426		12
TR_3	973	203	94	167	51	470		11
TR_4	972	206	58	240	63	601		9

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

Blood parameters. There were differences (P<0.05) between treatments in all the blood parameters. Total plasma proteins of animals on TR_2 (97.1g/l) were higher (P<0.05) than those on TR_4 (95g/l), TR_3 (92.3 g/l) and TR_1 (90.5 g/l) (Table 4). Rations with CRM (TR_2 and TR_4) had higher (P<0.05) plasma blood protein levels than those on HM (TR_1 and TR_3).

Maximum and minimum levels of Ca in the blood were highest in animals on ration TR_3 and were different (P<0.05) between rations (Table 4). Animals on rations containing FW had higher (P<0.05) levels of P than those with CSC (TR_1 vs TR_2) and the average P concentrations were 1.6mmol/l, 1.38mmol/l, 1.26mmol/l and 1.21mmol/l in animals on rations TR_4, TR_3, TR_2 and TR_1 respectively.

Plasma glucose was different (P<0.05) between treatment rations with the overall concentrations being 3.15mmol/l, 3.3mmmol/l 3.14mmol/l and 3.0mmol/l for TR_1, TR_2, TR_3 and TR_4 respectively (Table 4).

Discussion

The CP, NDF and ADF values for hay were within the range commonly reported for poor quality tropical forages (Göhl, 1981; Adepise and Oyedipe, 1985; Mtengeti, 1995). The CP for FW was lower than that reported by Ngate, (1997) and Mbamba, (2000), whereas the P value was higher. This is because the FW in Ngate's (1997) study included a significant proportion of whole fish and Mbamba (2000) worked on offal from marine fish. By-products

Table 3: The LS (means ±SEM) of live weight changes (LWC) (kg) of dairy heifers fed on different treatment ratios.

Weeks	Treatments				SEM	Pr > F	SIG.
	TR_1	Tr_2	TR_3	TR_4			
DMI (g/kg)	5.11[b]	5.47[a]	4.98[b]	4.89[c]	0.029	0.0001	***
LWC (kg)	29[a]	32	29	26	1.408	0.0856	NS
ADG (g/d)	500[b]	620[a]	460[b]	410[c]	0.005	0.0001	***
FCE (g/kg)	0.097[b]	0.116[a]	0.092[b]	0.085[c]	0.025	0.0004	***

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

Table 4: LS (means ±SEM) for the effect of treatment rations on different blood parameters.

Treatment	Protein (g/l),	Glucose (mmol/l)	Ca (mmol/l)	P (mmol/l)
TR_1	90.5[c]	3.15[b]	2.28[c]	1.21[c]
TR_2	97.1[a]	3.30[a]	2.36[ab]	1.26[c]
TR_3	92.3[bc]	3.14[b]	2.40[a]	1.38[b]
TR_4	95.0[ab]	3.0[c]	2.34[b]	1.60[a]
SEM	0.989	0.165	0.018	0.046
Pr>F	0.0001	0.0001	0.0001	0.0001
Significance	***	***	***	***

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

from Nile perch FW usually contain less flesh and more skeletal tissues (Hussein and Jordan, 1991a; Kjos, 2001). The CP value and P values noted could have been increased or decreased by the inclusion of N and minerals from the keratinous material and tissues e.g. scales and skin as no partitioning of the various carcass components was done after filleting. Johnson and Savage (1987) and Kjos (2001) reported several reasons for variation observed in the quality of FM/FW. According to the latter author, fish meals made from fish scraps contains higher ash and lower protein than meals made from whole fish.

The chemical contents of CSC and hominy meal were within the range reported by Thomke and Macha, (1986) and by Lekule *et al.* (1988). Cassava root meal in this experiment had higher values of CP, ash and crude fibre than those reported by Lekule *et al.* (1988). These differences could be attributed to variations in soil type, variety, stage of maturity at harvesting and the processing method used (Wanapat, 1999). Peels from the bitter varieties are also known to contain the N containing HCN (Lekule, 1990; Nguyen, 1996). They therefore have no much feeding unless cassava is dry processed (Nguyen, 1996; Bui Van Chinh and Le Viet Ly, 2001) to get rid of HCN.

The energy and protein content and the consumption of the treatment rations were within the range recommended for growing heifers (Singh *et al*., 1991; ARC, 1990; McDowell (1992). The minimum total DMI in the present study was 4.89 kg/day and was within the recommended range for growing heifers weighing 150-200 kg and gaining 0.5 kg/day of 4.2 to 5.6 kg/head/day (Kearl, 1982). Studies with heifers in the same weight band (150 to 200 kg) and fed on different diets containing FW or CSC had DMI ranging from 2.6 to 4.6 kg/head/day (Rocha *et al*., 1995). There seem to be synergistic interaction between CRM and CSC, which may explain the high DMI intake observed for TR_2. Cassava root meal has been reported to increase DMI in dairy cattle when included at 15 % of the diet DM (Silvester *et al*., 1977; Zinn and DePeter, 1991). Therdchai and Mikled (2001) substituted maize with CRM at the rate of 0, 50, 75and 100 %, and reported total DMI of 4.49, 6.24, 5.85 and 5.83 kg/day respectively.

FW is an excellent source of ruminal undegradable protein (RUDP). Animals fed on low quality roughages while receiving a high proportion of RUDP may experience low DMI and high plasma total protein (Hussein and Jordan, 1991b, Veira *et al.* (1994)). This would suggest that CSC was only partially degraded in the rumen while most of the FW was RUDP (Pham Kim Cuong *et al*., 2001). The superior performance of the animals on TR_2 was mostly due to the positive interaction between CSC and CRM, high DM degradation and higher ME content. Diet TR_4 on the other hand could not have effectively supported increased rumen organic matter digestion since some of the RUDP escaped intestinal digestion, absorption and passed out in faeces undigested.

Nocek and Polan (1984) reported increases in weight gain when CRM was included in ruminant diets. LuzMeyeles and Preston (1977) noted 30 % increase in weight in cattle fed CRM at 15 % of the DMI. Silvester *et al.* (1977) reported that cassava meal promotes higher gains because of its effects on improved intake. Heifers on all the rations showed a consistent weight increment of between 5 and 9 kg per fortnight. Animals receiving CRM and CSC showed superior weight gains than those on CRM and FW. This suggests an apparent synergistic interaction between CRM and the protein as earlier suggested. The high amylopectin content in cassava makes it a more suitable source of energy for ruminants than for monogastric animals (Kanjanapruthipong *et al*., 2001) as cassava is an excellent source of fermentable carbohydrates. Starch in cassava tuber makes the synthesis of rumen microbial protein more efficient when it is the main dietary source of fermentable carbohydrate compared to other sugars (Rowe *et al.*, 1980).

Heifers receiving CRM and CSC also had superior daily weight gain than those fed on CRM and FW. Cassava root meal offered at

50, 75 and 100 % of the daily ration combined with low quality roughages (rice straw) has been shown to promote weight gain of 866, 779 and 695 g/day respectively (Therdchai and Milked, 2001). Zinn and DePeter. (1991), found that daily weight gain was significantly greater when 15 % of the diet DM consisted of CRM. The high energy in CRM improves efficient of gain and growth (Smith *et al*., 1991; McDonald *et al*., 1998). In this case, CSC provided slowly ruminal degradable protein (RDP), hence improving total rumen digestible organic matter availability (Pham Kim Cuong *et al*., 2001). Such a scenario could provide more energy and higher rate of weight gain by the animals.

The normal range for blood plasma protein in grazing animals is 68-85g/l (Jain, 1986). This level increase in animals receiving high protein concentrates (Sawadogo *et al.*, 1991). Values in the present study were above the range for non-supplemented grazing animals. High total plasma protein noted in TR_3 and TR_4 suggests that FW was mostly digested in the lower gut after escaping ruminal breakdown. Veira *et al.* (1994) reported increased plasma albumin concentration when steers were fed with increasing levels of fishmeal. The significantly higher concentration of plasma protein in animals on TR_2 could be due to the sparing effect of the readily available energy from cassava. Hoover and Stokes (1991) have shown that when energy is readily available the animal is spared from using protein as an energy source, hence increasing the quantity mobilized into protein accretion. The amount of NH_3-N in the rumen could also have had an influence on the total protein concentration in the blood. Ruminal NH_3-N observed in this study was more than that required for microbial synthesis in the rumen. The excess ammonia could have been converted into body proteins (Singh *et al*., 1991; Hoover and Stokes, 1991).

The use of FW in practical ruminant diets could provide opportunities for reducing costs of inorganic mineral supplements, particularly Ca and P (Mbamba, 2000). The observations made on the availability of the two minerals when FW was included in the rations show the animals on TR_3 and TR_4 to have had significantly higher blood levels of Ca than those on TR_1. The high plasma Ca in TR_2 was not expected the animals on TR_3 and TR_4 received at least twice the recommended daily allowance for Ca. Judging from plasma levels; Ca appeared to be poorly available. However, as no attempt was made to assess urinary losses of Ca, it was not possible to quantify amount retained. The blood levels observed in this study suggest that FW could not provide adequate quantities of Ca as was expected, as cattle should have between 2.43 to 3.10 mmol/l of Ca (Kaneko, 1989). This level is however, known to be variable depending on many factors, e.g. age of the animals, physiological status and corresponding levels of P (McDowell, 1996).

Inorganic phosphate (P) is needed for the primary functions of growth, energy metabolism and reproduction (McDowell, 1992). The P levels observed in this study were lower than the recommended daily allowance (1.8 and 2.9 mmols/l) (Underwood and Suttle, 1999). Animals on TR_3 and TR_4 had levels approaching the recommended levels but were respectively 0.42 to 1.3 mmols/l below the recommended allowances regardless of the 30-46.5 % inclusion rate of FW. The amount of P in the rations showed that all animals received sufficient supply of P in the rations. The low plasma P levels would therefore, suggest poor uptake or low availability of P. The high oil and vitamin A content in FW might have interfered with Ca and P metabolism as high Vitamin A has been reported to negatively affect Vitamin D uptake and therefore P metabolism (McDowell, 1996; McDonald *et al*., 1998).

The level of plasma glucose observed is indicative of energy supply at tissue level. Animals starved on rapidly available energy would normally show high levels of ketones i.e. Non-esterified Fatty Acids, triglycerides and Beta-hydroxybutyrate. Adequate glucose levels indicate that the animal received sufficient energy supply from the diet. Results in this experiment suggest that animals in all the four treatment rations had glucose levels within the normal values for ruminants (Kaneko, 1989). Although CRM fed animals were expected to show high values of glucose (Aregheore, 1992), the inconsistency observed in this regard suggests that energy from CRM was best utilized when the diet contained CSC than FW.

Conclusions

Result of this study show that CRM can successfully replace HM as an energy source and that FW could replace CSC as a protein source and that the best results were obtainable where CRM was mixed with CSC. It is also concluded that CRM could be used alone as an energy source but that would require supplementation with protein rich feeds. As a protein supplement, FW can be successfully combined with energy at levels not exceeding 30 %. Recommended inclusion levels should be at 50 and 30 % for CRM and FW respectively.

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