Proceedings of the 13th ISTRC Symposium, 2007
pp. 521 - 529

Nutritive value of fresh cassava tubers, cassava root meal and cassava chips for growing - finishing pigs

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Abstract. Three experiments were carried out to evaluate the nutritive value of fresh unpeeled cassava tubers, peeled, soaked cassava tubers, cassava root meal and cassava chips as energy sources for growing-finishing pigs. The varieties used were sweet and bitter types. The initial weight of the pigs ranged from 12 to 38 kg and were slaughtered when they made 90 kg. Their feed intake, growth rate and carcass characteristics were determined. The digestibility trial involved 4 castrated males in a 4x4 Latin square design. Performance of pigs was comparable to pigs fed other energy sources (or commercial cereal based diet). Pig growth rate ranged from 478 to 660 g/pig /day. Digestibility and feed efficiency of cassava-based diets were high, although young pigs (below 20 kg) tended to develop gastro-intestinal disturbances and parakeratosis when fed fresh cassava. The carcass quality was slightly affected. Carcasses from pigs fed on cassava diets were leaner and heavier than those on other rations. The studies concluded that varieties of sweet cassava could be fed fresh to pigs either peeled or unpeeled or in form of cassava chips. Further, fresh cassava can be soaked in water for one day whereas cassava chips can be dried for 8 to 10 hours prior to feeding to reduce HCN levels. Cassava can constitute the only energy source in diets of pigs provided that such diets are well balanced for protein, minerals and vitamins. The use of cassava in livestock feeds will promote cassava production and provide a sustainable outlet for this underutilised but highly adaptable crop.

Introduction

The currently fast expanding global human population suggests that large proportion of meat will come from pigs and poultry for they are very prolific, have a high, growth rate, feed efficiency and short generation interval compared to ruminants. Moreover, the pig serves as a source of cooking fat (lard), biogas, manure and bristles/leather. Consequently, pig production is fast rising in many countries including Tanzania. However, there are constraints to pig production in Tanzania. Among these is the nutritional deficiency particularly energy and protein. These contribute to the low productivity of pigs. This is usually a result of competition for feed stuff with humans and other livestock. The supply of essential nutrients from commercial sources is becoming expensive. Milling by-products, which are the main feed sources for pigs, are relatively expensive and not accessible in many parts of the country. Feed costs account for about 70-80% of costs of raising pigs (Henry and Correa, 2003). So the majority of smallholder farmers feed their pigs on grass, brewery wastes and human food leftovers. Efficiency and economy of production can greatly be improved by use of fairly-balanced rations based on cheap and abundant energy source.

Recently, cassava has been found to be a cheap source of energy capable of replacing up to 50% of expensive cereals like maize, sorghum and wheat. Moreover, its starch is highly digestible (Balagopalam, *et al*., 1997). Cassava is resistant to drought, diseases, and pests and has no critical time of planting, thus is very suitable for low-income smallholder farmers. Nevertheless, it is deficient in proteins and vitamins, thus it must be supplemented with other source of feeds rich in these ingredients (Liliana, 1995; FAO and IFAD, 2000). The cyanogenic glucosides present in cassava have to be reduced to sage levels before feeding to animals. Cassava root meal presents a problem in animal feed, as it is very dusty, a condition, which may lead to reduced palatability and intake, and ulcerogenic conditions. Some of the measures suggested for improving cassava root meal include addition of oil, molasses and pelleting.

This present study was carried out to evaluate different processing methods and feed formulations to address the above problems as a means of promoting the use of cassava in livestock feeds.

Materials and Methods

This study was conducted at the Department of Animal Science and Production of Sokoine University of Agriculture (SUA), Morogoro, Tanzania. Three experiments were carried out using Large white and Landrace crosses of pigs. Economics of using cassava chips in pig rations was also evaluated. Carcass characteristics were also determined in all growth experiments.

Experimental procedures. In all trials, animals were dewormed two weeks prior to the start of the experiments and observed further for a period of 7 days. Feeding was done at 8 and 15 hours every day. Animals were allocated to dietary treatments by ensuring a balance of initial weight and sex. They were fed according to a standard scale. Water was supplied *ad libitum* during the day throughout the experimental period. Body weight changes were recorded weekly. Feed intake was recorded and feed conversion ratio (FCR) computed. The animals were slaughtered when they made 90 kg and their carcass characteristics determined. The economics of pork production was also determined.

In experiment 1, twenty-four pigs weighing on average 33 kg each were allocated to four dietary treatments in a completely randomised design. Diet 1 was a control diet based on maize and sorghum as energy sources. Diet 2 was a complete diet based on cassava root meal (CRM); diet 3 was made of raw (peeled and soaked) cassava root fed separately with protein concentrate (cafeteria system), whereas diet 4 was based on rice polishing. Fresh cassava tubers were purchased from nearby farms and the varieties involved were all sweet viz. Kigoma, Mzungu, Msenene and Ndunga. In treatment 3, the tubers (CRT) were washed, peeled and soaked in static water for 24 hrs. Before being fed, the tubers were chopped. The pigs were first offered 1.0- 1.5 kg of the protein concentrate. After clearing, they were offered the peeled cassava semi-*ad libitum* by closely monitoring the daily intake so that no refusals were collected. Each day's feed offered was determined by feed consumption the previous day. The cassava root meal (CRM) was prepared by peeling the cassava, chopping, dying and milling. The hydrocyanic acid (HCN) content in the cassava root meal was determined. Metabolic studies were also done to determine the digestibility and metabolisable energy content of the diets, and nitrogen retention of the pigs. A 4x4 Latin square design was used. A preliminary period of 5 days was followed by a collection period of 7 days during which faeces and urine were collected.

In experiment 2, twelve pigs weighing on average 19 kg were allotted to three dietary treatments by sex, weight and litter. In treatment 1, the animals were fed fresh unpeeled cassava and protein concentrate (in the same way as diet 3 above). Cassava was fed semi- *ad libitum*. The protein mixture was fed at a rate of 1.0 – 1.5 kg/pig/day. Diets 2 and 3 each consisted of 55% peeled cassava root meal with different proportions of cotton seed/sunflower cake.

In experiment 3, eighteen growing-finishing pigs weighing about 18 kg were allotted to three dietary treatments; diet 1 was a control diet, diets 1 and 2 contained 67 and 78% hominy meal, respectively, while diet 3 contained 60% cassava chips from bitter varieties (mainly Kalolo). The chips were prepared from 2 villages (Miswe & Zogowale, Kibaha) using a specially designed cassava chipper. Diets 1 and 3 were formulated for A-Z Animal Feeds (Dar es Salaam) for use as commercial pig feeds.

Data analysis. DM, OM, CP, CF, EE, Ash, NFE, Ca and P of experimental diets were determined using standard procedure (AOAC, 1990). Data for growth rate, digestibility, FCR, economics of cassava diets and carcass characteristics were analysed according to the General Linear Model (GLM) of the Statistical Analysis System (SAS, 1998)

Results

Chemical composition and digestibility. The chemical composition of cassava and diets used in the study is shown in Tables 1 and 2. Fresh cassava tubers had DM content ranging from 34.4 to 38.3 %. Cassava had very low protein content and negligible amounts of amino acids. Cassava chips from bitter varieties (Kalolo), which contained unpeeled cassava, had relatively high levels of crude fibre (3.6%). Unpeeled sweet cassava contained 3.3 % CF. Peeled sweet varieties of cassava had CF content of 2.8-3.5%. Peeling reduced the fibre and ash contents. The peels from sweet varieties contained 26.2% NDF, 5.8% ash and 5.4% CP and formed 20 % of the tuber. The ash content of unpeeled cassava was 3.3% while for peeled cassava it ranged from 1.6 to 3.1%. The starch content in peeled sweet varieties ranged from 81 to 88% while for the peel it was only 16 %. The hydrocyanic acid (HCN) content in CRM was 25 mg/kg.

The diets contained 13-18% CP. The digestibility of the diets was high (79.4 to 86.7 %DMD) and followed closely the crude fibre content of the diets. The results revealed that CRT diet and rice polishing diet were significantly ($P<0.05$) more digestible than the maize/sorghum diet and the CRM diets especially with respect to DM, OM and CP. Consequently the CRT and rice polishing diets had higher metabolisable energy (15.4 & 16.1 MJ/kg DM) than the rest of the rations.

Growth performance, feed intake and feed conversion efficiency of growing pigs. The daily gain, feed intake and feed conversion ratio of pigs are presented in Table 3. The highest feed intake and growth rate were

Table 1: Chemical composition of ingredients and diets used in experiment 1 and 2 (%DM).

Item	DM	OM	CP	CF	EE	Ash	NFE	Ca	Lys	Meth
Experiment 1										
Diet 1 (control	91.2	89.7	17.9	19.6	6.2	10.5	54.9	0.7	-	-
Diet 2 (CRM)	92.1	84.4	15.6	7.8	2.5	5.9	68.1	0.7	0.6	0.5
Diet 3 (CRT)*	92.8	92.2	17.2	9.5	5.7	7.2	96.0	0.7	0.8	0.6
Diet4 (RP)	94.0	93.5	15.3	14.7	7.4	6.5	66.0	0.6	1.0	0.7
Prot. conc. (for diet 3)	92.9	88.3	32.7	10.3	7.8	11.7	37.5	2.2	1.5	1.1
Cassava tubers	34.4	96.9	2.1	3.3	0.6	3.1	91.1	0.1	-	-
Cassava root meal	89.0	-	2.4	3.5	0.5	1.6	93.8	0.7	-	-

*Based on DM consumption of 52% cassava root tubers.
CRM = Cassava root meal, CRT = Cassava root tubers (fresh), RP = Rice polishing, Prot.Conc = Protein concentrate, SC = Sunflower cake, CSC = Cotton seed cake, Lys= Lysine, Meth = Methionine+cystine.

Table 2: Chemical composition of ingredients and diets used in Exp 2 and 3 (%DM)

Item	DM	CP	CF	EE	NFE	Ash	Ca	p	Lys	Meth
Experiment 2										
Prot. conc	94.3	27.0	17.5	8.4	29.4	17.7	2.1	1.1	1.4	1.2
Cassava tubers	38.4	1.70	3.5	0.6	90.9	3.2	0.3	0.2	-	-
Cassava peels	93.4	5.4	-	1.3	-	5.8	0.8	0.1	-	-
Diet1* (CRT+CSC+SC)	92.3	13.9	10.4	4.5	61.7	10.4	1.0	0.6	0.6	0.5
Diet2 (CRM+CSC)	91.9	15.2	7.7	4.8	67.0	5.4	1.1	0.6	0.7	0.5
Diet3(CRM +CSC+SC)	93.2	13.4	11.8	4.2	61.4	9.11	0.9	0.6	0.6	0.6
Experiment 3										
Cassava chips	88.6	5.3	3.6	0.7	69.9	3.3	0.7	0.5	-	-
Diet1(hominy based diet)	94.8	14.2	9.8	2.3	53.7	7.2	0.75	0.6	-	-
Diet2 (hominy based diet)	95.0	15.1	9.9	5.2	54.1	7.3	0.8	0.6	-	-
Diet3(cassava based diet)	94.1	14.7	10.7	2.0	50.3	8.4	0.6	0.5	-	-

*Based on DM consumption of 56.2% fresh cassava roots and 43.8% protein concentrate.

observed in experiment 1. The diets in this experiment had the highest CP content. However, pigs in this trial had the poorest feed conversion. The other treatments were comparable. In experiments 1 & 2 pigs fed fresh cassava consumed 406 kg of cassava and 152 kg protein concentrate, and 383 kg of cassava and 112 kg protein concentrate per pig respectively, from 20 to 90 kg. The average daily gain in all the experiments ranged between 479 and 660 g/day. Feed intake was generally high in all experiments indicating that all diets were well formulated. The most interesting results were obtained in experiment 3 where the diet based on cassava chips outperformed the others. Feed conversion ratio was 2.6 as compared to 3.9 and 4.3 for the hominy meal based diets. Growth rate was also significantly higher for the cassava chips based diet. In experiment 1, pigs fed the soaked cassava consumed 3.49 kg of cassava and 1.2 kg protein concentrate. Pigs fed cassava diets developed skin lesions, which were more severe in the raw cassava group. Excessive soaking led to breaking of the starch and pigs disliked the cassava. In experiment 2, although the plan was to feed fresh raw unpeeled cassava, the pigs consistently peeled the cassava, ate the parenchyma and left out the peels. It was therefore decided to peel the cassava before feeding. Pigs fed on fresh cassava tubers experienced reduced feed intake associated with scouring/ gastrointestinal disturbances. The conditioned was well expressed in pigs with body weights less than 25 kg. Severe diarrhoea occurred during the 6th week. Pigs fed fresh cassava had severe skin lesions indicating deficiency of zinc.

Carcass characteristics and organ weights of pigs. Most of the carcass characteristics and organ measurements did not differ (P>0.05) significantly, though pigs fed on cassava diets tended to have leaner carcasses compared to other treatments. The carcass characteristics were closely related to the content of crude fibre in the diet. There were no significant differences in carcass characteristics and organ weights between sexes, though barrows tended to have thicker back fat, heavier kidney weight, shorter carcasses and less gut fill than gilts.

Economics of using cassava in pig rations. Table 4 shows the cost of production of pork

Table 3: Growth performance, feed intake and conversion efficiency of growing –finishing pigs.

Parameter	Dietary treatment				Se M
	Control	CRT	CRM	RP	
Experiment 1					
Initial weight (kg)	33.8	32.0	34.0	31.5	2.52
Final weight (kg,)	89.4	89.6	89.2	89.0	2.60
Feed intake g DM/pig/d	2581	2555	2437	2467	120.4
Daily gain (g)	625	635	658	660	46.90
Feed conversion ratio (FCR)	4.44	4.19	4.50	3.69	0.90
Experiment 2					
	CRT	CRM+SC	CRM+CSC+SC		
Initial weight (kg)	19.0	20.5	18.0		1.91
Final weight (kg)	89.8	89.8	90.3		0.48
Feed intake, g/pig/d	1873	2102	2025		120.10
Daily gain (g/d)	551.0[a]	646.0[b]	589.0[a]		46.60
Feed conversion ratio	3.45	3.36	3.56		0.34
Experiment 3					
	Hominy meal based	Hominy meal based	Cassava based diet		
Initial weight (kg)	17.9	18.2	18.8		0.23
Final weight (kg)	58.8	61.4	64.6		0.46
Feed intake g DM/pig/d	2100	2000	1880		62.0
Daily gain (g/d)	479[a]	515[a]	546[b]		42.4
Feed conversion ratio	4.3	3.9	2.6		0.12

[ab,] Values within rows bearing different superscripts are significantly different (P<0.0.5).

Table 4: Economics of using cassava in pig diets.

Parameter	Dietary treatment		
	1	2	3
	Hominy based diet	Hominy meal based diet	Cassava based diet
Feed cost/kg (Tshs)	100	100	97
Feed/pig,kg	175.9	168.5	131.7
Feed Cost per pig Tshs	17590	16850	12775
Labour + Medication cost/pig (Tshs)	11830	11830	11830
Total Revenue/pig (Tshs)	43800	46400	49600
Total cost/pig (Tshs)	29420	28680	25605
Net profit/pig (Tshs)	14380	17720	23995

using different diets. The diet based on cassava chips which had the best performance showed higher returns and lower cost of production. Consequently it produced higher gross margins and net profit.

Discussion

Chemical composition and digestibility. The DM in cassava root meal and chips of 89 % is comparable to values obtained by Lekule *et al*. (1990), Tewe (1994), Shrestha (2002) and Mutayoba *et al*. (2003). The low content of protein (1.7-3.3%) in cassava in the present work is similar to that reported by other workers (Sommert *et al*., 1999 and Kainjanapruthipong *et al*., 2001). Lekule *et al*. (1990) have documented slightly higher values ranging from 2.8 to 4.6 %. Cassava is deficient in protein; this is because about 40 to 60% of the total N is in the form of non-protein nitrogen (NPN). Cassava was inferior to rice polishings and maize in protein and amino acids content. Values obtained in this study are similar to values documented by Wyllie and Lekule (1980). The observed high Ash and CF in unpeeled cassava is partly influenced by the degree of contamination with soil. In addition, the variation could be attributed to differences in the method of processing and moisture content. However, the values are invariably lower than values reported by Lekule *et al*. (1990) for CRM. Peeled cassava had very high content of NFE (91-94%) while unpeeled cassava contained 70% NFE. This is in line with the work of Sommert *et al.* (1999) that well prepared CRM from peeled tubers contain about 90% NFE. The range of CP content between 13.5 and 18% of the diets used in the present experiments was within the dietary CP of 14 to 18% recommended by NRC (1979) for growing-finishing pigs. The higher CF in most of the diets can be attributed to high content of such component in sunflower cake, sunflower seed cake and unpeeled cassava incorporated in the formulation of such rations.

Growth performance, feed intake and conversion efficiency of growing pigs. The overall growth rate observed in this study was relatively high and comparable to that of Oke (1984). In experiment 3, the diet which had cassava chips, had better feed conversion ratio compared to hominy meal based diets. The mean value for diet 3 (2.6%) was slightly lower than 2.8 % reported by Israel (1992) who fed cassava root meal to pigs. The use of cassava root meal did not significantly reduce feed intake. Lekule *et al*. (1992) observed only slight reduction in intake in CRM diets although Muller *et al*. (1974) reported that cassava based diets have ulcerogenic effects upon the mucosa and cause irritation to the eyes and respiratory organs leading to reduced intake. The lower intake and gains in pigs fed raw cassava could be due to inability of the relatively young pigs to cope with the bulk and low palatability. It is also possible that the diarrhoea, which could be a result of HCN in the fresh cassava, leads to lower feed intake and growth rate (Gomez, 1977). This finding suggests that fresh cassava should not be introduced to young pigs of less than 20 kg live weight and only moderate amount up to about 30 kg live weight. The possible cause of the skin lesions is mineral deficiency especially zinc as demonstrated by Maust *et al*. (1992) leading to parakeratosis. Fortification of cassava based diets with fat; Vitamin B_{12} has proved to improve pig performance fed cassava (Hutagalung, 1977). Skin lesions, which occurred when pigs were fed 45-60% cassava, were alleviated following a double dose of vitamins and minerals. The low mineral and vitamin content in cassava coupled with the use of some nutrients (methionine + cystine and cobalt) for detoxification and high levels of oxalic acid in cassava roots renders these minerals unavailable. Oxalic acid reduces the availability of Ca and P. The incidence of diarrhoea in young pigs fed cassava has been observed by Maust et al. (1972). Hew and Hutagalung (1977) have suggested that scouring occurs if pigs are fed cassava high in HCN. The peeling of the cassava by pigs fed on fresh cassava is a clear indication that sweet varieties of cassava have the HCN concentrated in the peel. Peeling removes most of the cyanide in sweet varieties. It is documented by CIAT (1978) that the total cyanide in the cassava peels is about 15 to 20 times higher than in the parenchyma in sweet varieties and about twice in bitter varieties. Ways of detoxifying cassava include peeling, boiling, chopping and drying, soaking or fermentation. Chopping of the tubers initiates the action of the enzyme linamarase on the hydrolysis of glucosides, resulting in HCN liberation (Gomez, 1977). Simple drying of sliced roots was shown to be capable of removing up to 90 % HCN and meal produced from bitter varieties had relatively low HCN contents (100-150 ppm on DM basis) (Gomez, 1977).

Cassava diets present a problem of palatability and ulcerogenic effects. The addition of sugarcane molasses (Wyllie and Lekule, 1980), fat, fishmeal, pelleting (Muller, 1977) have been found to improve palatability resulting in higher feed consumption and faster growth rate. In the present study, chopping and soaking the cassava for one day seemed to be effective in reducing the HCN to insignificant levels. For commercial utilisation of cassava, dustiness must be avoided; hence cassava root meal is not suitable. The results of experiment 3 are interesting. Using cassava chips processed with a cassava chipper produces cassava of the right particle size. These chips do not need further milling and dries within a short time.

Economics of using cassava in commercial feeds. The economic analysis (Table 4) showed that feeding growing pigs with cassava-based rations was cost-effective. This is reflected in the low feed conversion ratio and high growth rate of pigs fed cassava chips based diet. The economics of using cassava will depend to a large extent on the availability and cost of alternative energy sources.

Digestibility. The higher digestibility of cassava based diets compared to the control (maize/sorghum) is supported by the results of Sonaiya and Omole (1982) who reported that cassava diets had a higher digestibility of DM and energy than sorghum diets. However, the coefficients of digestibility were much lower than those observed in this study. The higher digestibility of cassava-based diets has been suggested by Gomez and Valdivieso (1983) to be caused by physio–chemical characteristics of cassava starch granules.

Carcass characteristics and organ weights of pigs. Pigs fed on cassava diets tended to deposit less fat as exhibited by lower kidney fat. These findings concur with those of Sonaiya *et al* (1982) that the highest level of cassava diets produced leaner carcasses. Pigs fed on fresh cassava and cassava root meals had thinnest back fat. However, this was more a reflection of the fibre content in the diet. Most organ measurements were not significantly (P>0.05) influenced by cassava a fact supported by results of Sonaiya *et al.* (1982).

On the other hand, heavier thyroids observed for the control diet group could be caused by high proportions of goitrogenic substances in diet 3 than in the other diets.

Conclusions

The following conclusions can be drawn from the present study:

1. For small scale pig producers in cassava growing areas, raw, sweet varieties can be fed to finishing pigs. Peeling, which is labour intensive can be avoided, as the pigs will peel them. Alternatively, the cassava can be soaked for one-two days and be fed to growing finishing pigs. About 390 to 406 kg of cassava and 112 to 152 kg protein concentrate (25-35%CP) are required to raise a pig from 20kg to 90 kg.

2. For good performance, cassava based diets must be well fortified with high quality protein, minerals and vitamins to avoid deficiency symptoms.
3. Cassava can be used in commercial pig rations cost-effectively. To eliminate the problem of HCN toxicity and avoid dustiness, the most appropriate processing method is the use of cassava chipper, which produces cassava chips of the right particle size.

Acknowledgments

The authors are grateful to the generous financial support from TARP II-SUA Project that enabled this research to be successfully carried out.

References

A.O.A.C. 1990. Association of Agricultural Chemical official methods of Analysis, 15th Edition, Arlington Virginia, USA. pp. 807-809.

CIAT (1978). Swine Nutrition Annual Report. CIAT, Cali, Colombia.

FAO and IFAD 2000. The World Cassava Economy Facts, trend and outlook. Vol. 4

Gomez, G. 1977. Lifecycle swine feeding systems with cassava. In: Nestel, B. Graham, M. (eds). Cassava as animal feed. Proc. Workshop Univ. Guelph 18-20 April 1977, Ottawa, Canada. IDRC-095e: 65-71

Gomez, G. and Valdivieso, M. 1983. Cassava meal for baby pig feeding. Nutr. Rep. Int. 3:547-558.

Grandin T. 1998. Objective scoring of animal handling and stunning practices in slaughter plants. J Amer Vet Med Assoc 212:36-93.

Henry, G. and Correa, C. 2003. Economics of cassava product in animal feeding. Current status and potential use in Asia. *Cassava Workshop* 22-28, Oct 2002, Malang, Indonesia

Hutagalung, R.I. 1977. Additives other than methionine in cassava diets. In: Nestel, B., Graham, M. (eds). Cassava as animal feed. Proc. Workshop Univ. Guelph 18- 20 April 1977, Ottawa, Canada. IDRC-095e: 18-32.

Israel, S. H. 1992. Amino acid supplementation of cassava and hominy feed based pig rations. M.Sc. Thesis, Sokoine University of Agriculture, Morogoro, Tanzania, pp. 46-52.

Kanjanapruthipong, J., Buatrug, U., Juttupornpong, N. and Chaonthai, W. 2001. Cassava chips and ground nut corn as source of total non fibre carbohydrates in total mixed rations for dairy cows**.** Asian-Australian Journal of Animal Science 14(2): 206-210.

Lekule, F.P., Jorgensen, H., Fernandez, J. and Just, A. 1990. Nutritive value of some tropical feedstuffs for pigs. Chemical composition, digestibility, and metabolisable energy content. Animal Feed Science and Technology 28:91-101.

Lekule, F.P., Sarwatt, S.V., Ogle, B.O. and Thomke, S. 1992. Energy and protein sources for small-scale pig producers in the tropics. Journal of the Zimbabwe Soc. Anim. Prod. 4:79-81.

Liliana, O. 1995. Effect of protein supply in cassava root meal based diets on the performance of growing–finishing pigs. Journal of Livestock Research for Rural Development. 3(2):1-11.

Muller, Z., Chou, K.C. and Nah, K.C. 1974. Cassava as a total substitute for cereals in livestock and poultry rations. World Anim.Rev. 12(1): 19-26.

Maust, L.E.; Pond, W.G. and Scott, M.L. 1972. Energy value of a cassava –rice bran diet with and without supplemental zinc for growing pigs. J. Anim. Sci.35(5): 953-957.

Mutayoba, S.K., Lekule, F.P., Sarwatt, S.V., Laswai, G., Shem, N.M., Malole, J.L., Mbwile, R.P., Mtunda, K. and Michael, S. 2003. Assessment of cassava commerciali-sation and the effect of feeding cassava on performance of broilers. In: Proceedings of the 2nd Joint Workshop between Sokoine University of Agriculture- TARPII-SUA and The Ministry of Agriculture and Food

Security, 28-30 MAY, 2003, Morogoro, Tanzania

National Research Council NRC, 1979. Requirement of swine No.2. National Academy of Sciences, NRC, Washington D.C. U.S.A pp 52.

Shrestha, N.P., Edward, S.A. and Richards, J.F. 2002. Factors affecting reproductive performance in the Nepalese Pakhribas pig: Effect of nutrition and housing during gilt rearing. Asian –Australasian Journal of Animal Sciences 15(1): 72-78.

Sonaiya, E.B., Omole, T.A. and Adegbola, A.A. 1982. Effect of methionine supplemented to cassava meal diets on performance of and carcass characteristics and some weights of growing finishing pigs. Nutr. Rep. Int. 26(1): 25-34.

Sonaiya, E.B. and Omole, T.A. 1983. Cassava meal and cassava peel meal in diets of growing pigs. Anim. Feed. Sci. Technol. 8:211-220.

Sommart, K., Wanapat, M., Rowlinson, P., Parker, D. S., Climee, P. and Panishying, S. 2001. The use of cassava as an energy source for lactating dairy cows fed with rice straw. Asian-Australian Journal of Animal Science 13(8):1094-1101.

Tewe, O.O. 1994. Indices of cassava safety for livestock feeding. International workshop on cassava safety, Ibadan, Nigeria, March 1-4, 1994. Acta. Horticulture 375:41-249.

Walker, N. 1985. Cassava and Tallow in diets for growing pigs. Anim.Prod. 40 (2):345-350.

Wyllie, D. and Lekule, F.P. 1980. Cassava and molasses for fattening pigs under village conditions in Tanzania. Trop. Agr. (Trinidad) 57(3): 267-276.