Use of cassava products in poultry feeding
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INTRODUCTION

Shortage of cereals has recently been a serious issue in several regions of the world; in many of these the use of cereal products as livestock feeds is increasingly unjustified in economic terms. Nonruminants like poultry are markedly affected by such a trend. Therefore, there is a need to exploit cheaper energy sources, to replace expensive cereals for livestock production, to relieve the food-feed competition in the future.

Cassava is very appropriate for this purpose. Substantial efforts have been made, in the past few decades, to replace cereals with cassava in poultry feeding. The results, in terms of its feeding value, nutritional problems encountered, biological responses and productive performances of chickens fed cassava products, have exhibited wide variability. Available reports in the literature have showed variation and conflicting results regarding, what products can be used, how they can be fed and how much cassava can successfully be fed to each poultry type.

It is the intention of this paper to review and re-assess the present state of knowledge concerning the use of cassava products in poultry feeding and to evaluate what is still needed to help establish reliable and practical guidelines by which more efficient utilization of cassava as poultry feed can be accomplished.

NUTRITIVE VALUE OF CASSAVA FEED PRODUCTS

Kind of cassava feed

The most common type of feedstuff produced from cassava roots are, root chips and pellets. Chips are the dried (normally in the sun), shredded root and are of variable size, shape and quality depending on rate of drying and contamination during the processing. The chip can then either be directly ground and used in feed mixing or pelleted. The root pellet is a uniform cylindrical product of about 0.5 to 0.8 cm diameter and 1.0 to 2.0 cm long. Pelleting is done to reduce storing space and dust problems and thus eases transportation.

Cassava leaf is another potential feed source for poultry. The leaf blade accounts for 10 to 40% by weight of the plants aerial part, depending upon the age and ecological condition of the plant. Leaves can be harvested within 4 to 5 months of planting, without adversely affecting root production, yielding up to 10 tonnes of dry foliage per hectare. After drying, the leaf or foliage can be ground into meal which is a good source of protein and carotene for poultry.

Other feed products from cassava are of limited significance and not normally used in feeding due to their high labour requirements and high costs in processing. These include the dried products from the fermented or ensiled root carried out to detoxify it or to increase its protein content, dried cassava waste from starch factories and cassava peel meal. Data on their use in poultry feeding are limited.

Nutritive profile

It is widely known that cassava root products are rich in carbohydrates but low in protein, amino acids and all other nutrients and thus are used mainly as sources of energy. In using cassava root products as cereal substitutes, approximately 15 to 20% extra protein source is needed (Table 1). Cassava leaf (CLM) and foliage meal (CFM) contain moderate levels of crude protein and amino acids, mineral, vitamins and carotene but are rather high in crude fibre making them only fair sources of protein for nonruminants.

Both root and leaf products contain widely ranging levels of cyanogenetic glycosides, namely linamarin and lotaustralin. Upon enzymatic hydrolysis during practical processing, hydrocyanic acid (HCN) is liberated from these, rendering the dried products safe feeds for all classes of livestock and poultry. However, the residual glycosides in the products can still cause some degree of deleterious effects on the performances of cassava-fed animals. Enriquez and Ross (1967) demonstrated that supplementation of methionine at 0.15 to 0.20% of diets could help overcome the HCN toxicity and restore chick performances to normal levels.

TABLE 1. **Chemical composition of cassava products as compared to maize, soyabean meal and their mixture**

		Composition, % of dry matter			
Constituent:	**Cassava root[1] meal (CRM)**	**Maize[2]**	**Soyabean[2] meal (SBM)**	**Mixture of[1] 85 CRM + 15 SBM**	**Cassava[3] meal (CLM)**
Crude protein	2.50	8.50	49.40	8.88	23.20
Ether extract	0.30	3.80	0.90	0.40	4.80
Crude fibre	3.50	2.00	9.20	3.64	21.90
Ash	3.80	1.10	3.50	3.40	7.80
WFE	89.90	84.60	37.00	83.68	42.20
Minerals					
Calcium	0.18	0.03	0.32	0.20	0.37
Phosphorus	0.09	0.27	0.73	0.18	0.58
Amino acids					
Lysine	0.04	0.25	6.32	0.47	7.11[1]
Methionine and cystine	0.02	0.25	3.04	0.23	2.53[1]
Threonine	0.05	0.36	4.14	0.33	4.70[1]
Tryptophan	0.01	0.05	1.30	0.10	1.09[1]
Metabolizable energy poutry	3,145	3,524	2,606	3,047	1.59[4]
ME Kcal/kg					

[1] *Adapted from Muller et al., 1974*
[2] *US, NRC., 1984*
[3] *Devendra, 1977*
[4] *Hutagalung et al., 1974*

The literature on the nutritive value of cassava products contains a wide variation in the published values, especially where these were obtained by biologically testing. This was mainly caused by inaccurate definition of the tested products. Evidence clearly shows that cassava products from different origins, with regard to varieties, ages at harvest, ecological conditions of plant growth and processing methods contain widely varying levels of nutrients, energetic values and HCN. Data on the energetic value of the products (Table 2) are good examples of such a variation. It was, therefore, agreed among scientists attending the workshop on the utilization of cassava as feed at the Guelph University in 1977 that all researchers should exactly define, in scientific reports, the feed products being used in their studies to enable realistic comparisons to occur.

VALUE OF CASSAVA PRODUCTS IN POULTRY FEEDING

Cassava root meal

Cassava root meals contain a range of metabolizable energy values for poultry from 2.87 to 4.27

kcal ME/g of dry matter. They also contain very low levels of protein (2.5% of DM) and are deficient in all other nutrients. In formulating a balanced poultry ration, there is therefore need to supplement the root products with protein, amino acids, fat, minerals and vitamins at higher levels than when using cereal-based diets. Earlier attempts to replace cassava root products for cereals in poultry rations resulted in generally depressed performances of cassava-fed chickens (Tobayayong, 1935; McMillan and Dudley, 1941; Vogt, 1966). This was probably due to variations in HCN levels in the cassava used and the composition and make-up of diets. In their classical study, Enriquez and Ross (1967) overcame the growth depression by supplementing methionine at 0.15 and 0.20% of 50% cassava diets.

They concluded that a part of the methionine was needed to make up for nutrient deficiencies, as soyabean meal was used as the main source of protein, and the rest was for HCN detoxification. They also noted that the addition of soyabean oil at 3.7% of the methionine supplemented diets further improved chick performances, suggesting that energy was a second limiting factor. A similar response was reported by Olson *et al.* (1969a) who subsequently (Olson *et al*., 1969b) showed that the supplementation of cystine at 0.40% of a 45% cassava diet gave comparable results to the 0.20% supplemented methionine.

TABLE 2. **Energetic value of cassava products in poultry rations**

Poultry type	**Age (wks)**	**Energetic value**			**Source**
		CRM		**CLM**	
		ME, kcal/g	**Note**	**ME, kcal/g**	
Broiler		3.76	=	=	Olson *et al*., 1969b
Leghorn	2–4	4.31	=	=	Maust *et al*., 1972
Broiler	2–4	3.23	=	1.5	Hutagalung *et al*.,1974
Poultry	=	3.65	=	=	Muller *et al*., 1975
Leghorn	2–4	3.78	(40% diet)	=	Fetuga and Oluyemi,
	2–4	3.88	=		1976
Broiler	=	2.87	(92% of maize)	=	Stevenson and Jackson, 1981
Poultry	=	=	=	1.87	Rajaguru and Ravindran, 1983
Broiler cock	10–13	4.27	Prewashed chip 98.9% diet Conventional chip		Khajarern *et al*., 1982
		3.66	98.8% diet Oven dried chip 98.9% diet		
		4.02	Precooked chip 98.9% diet Hard pellet 98.9% diet		
		3.56			
		3.98			
Leghorn	4	=	67% TDN—10% diet		Yoshida, 1970
Broiler	=	=	98.6% Dig. MFB		Szylit *et al*., 1977
Broiler			94,3% of DM was available Energy		Agudu and Thomas, 1982

Works subsequent to this period was carried out to establish the optimum levels of inclusion and types and levels of supplementation of cassava-based rations to make them precisely meet the nutritional needs of poultry at the most economical cost. Maximum possible levels of inclusion in various types of poultry rations have been reported (Table 3). The data again shows variations in the reported levels. The variations, apart from being caused by the varying origins of the tested cassava, are due to differences in the chicken breeds, types, kinds and levels of production. In addition, the form, make-up and composition of diets, levels and types of supplementation, and plane of nutrition are additional factors contributing to these variations. Results from these trials lead to the following general conclusions concerning feeding cassava root to poultry:

a. Cassava root products can be successfully used as substitutes for cereals in nutritionally balanced rations for almost all classes of poultry. However, it should be noted that broilers tend to tolerate diets containing high levels of cassava better than layers, where egg production and quality are particularly susceptible to the type of imbalances commonly found in high cassava diets. Also, partial substitution of cassava for cereals tends to support better chick performance than the control diets or where total substitution occurs. At high level of substitution, efficiency of feed utilization tends to be depressed before growth reduction is noticed.

b. t is important to assure that cassava based rations are balanced for all nutrients and in particular energy, sulphur containing amino acids, phosphorous, zinc, iodine and vitamin B_{12} (Hutagalung, 1977). The normal methionine supplementation of high cassava based diets is 0.2 to 0.3%. It has been questioned, however, whether the extra methionine is really needed for HCN detoxification (Adegbola, 1977). According to him, the depressed reduction of urinary thiocyanate in rats does not support the hypothesis. In addition, Gomez *et al*. (1984) observed no benefit from 0.2 to 0.3% methionine supplementation of high cassava (65%) diets fed to all classes of pig. They also showed that when least cost rations containing 3% fish meal and low cassava inclusion, were used in pig diets (30% in breeder, 40% in starter and 20–30% in growerfinisher), no supplemental methionine was needed. For poultry, no such comparable data is available.

TABLE 3. **Maximum possible inclusion levels of cassava products in poultry rations**

Type:	**Diets**	**Maximum cassava levels, % of ration**					**Source:**
		Starter	**Grower**	**Finisher**	**Developer**	**Layer**	
Root meal Broiler	P	58.0	=	58.0	=	=	Chou and Muller, 1972
	NS	60.0	=	60.0	=	=	Christensen *et al*., 1977
	P	57.5	=	57.5	=	=	Khajarern *et al*., 1979
	P	50.0	=	50.0	=	=	Stevenson & Jackson 1981
LayerHeavy	P	40.0	60.0	=	60.0	50.0	Khajarern *et al*., 1979
Leghorn	M	15.0	30.0	=	40.0	40.0	Eshiett and Ademosun, 1976
Heavy	M	=	=	=	=	60.0	Hamid and Jalaludin, 1972
Leghorn	M	=	=	=	=	50.0	Enriquez and Ross, 1972
Foliage and leaf meal Broiler							
CFM	M	2.50	=	2.50	=	=	Montilla *et al*., 1973
CFM	P	20.0	=	20.0	=	=	Montilla *et al*., 1976
CFM	M	10.0	=	10.0	=	=	Siriwadene & Ranaweera, 1974
CLM	NS	20.0	=	20.0 (+3% SBO +0.25% Met)			Ravindran *et al*., 198
Layer	NS	20.0	Male	20.0 (+3% maize			Ross and Enriquez,1969
CLM			Leghorn	oil + 0.5% Met)			
CLM	P	=	16.5	=	16.5(Heavy breeds)		Khajarern *et al*., 1980

Note: *P = Pellet diet;*
M = Mash diet;
NS = Not specified;
SBO = Soybean oil;
Heavy = Heavy layer breeds

c. Palatability of cassava-based ration is an important factor limiting feed intake of poultry. Physical properties such as dustiness and bulkiness are closely related to palatability and limit feed intake. Further processing of cassava-based diets including pelleting, the addition of molasses or fat to eliminate dust and improve texture of the diets, supported significantly better chick performance than the use of mash diets.

Apart from improving the palatability of feeds, fat supplementation has also been reported to supply essential fatty acids needed for normal egg size as well as provide additional energy to allow the diets to meet the requirements of chickens. Improved body weight and feed efficiency are normal responses to the addition of fats to cassava-based diets. However, Gomez *et al*. (1987) showed that a 5% increase in ME, using supplemental vegetable oil or tallow, had no beneficial effect on body weight of broilers fed mash diets containing 20–30% cassava meal (Table 4). Although the feed efficiency of the fat supplemented chicks was significantly better than the unsupplemented ones, the use of fat supplementation could not be economically justified.

d. Cassava root products are deficient in carotene and other carotenoids. Consequently, supplementation of cassava-based diets with these compounds is needed for the maintainance of normal egg yolk and broiler skin pigmentation.

TABLE 4. **Effects of added vegetable oil and tallow to cassava-based diets on broiler performances[1] (Gomez *et al*., 1987)**

		Treatments					
	Cassava level, %	**0**	**0**	**20**	**20**	**30**	**30**
Performance	**Relative ME, %**	**100**	**105**	**100**	**105**	**100**	**105**
Vegetable oil							
Starter (0–4 wk)	BW gain,g Feed/gain	768[b]	714[b]	793[b]	811[b]	799[b]	795[b]
		1.76[b]	1.81[b]	1.68[b]	1.61[b]	1.63[b]	1.62[b]
Final BWgain,g (0–8 wk)	2,068 Feed/gain	2,048	2,153	2,167	2,077	2,141	
		2.28[b]	2.29[b]	2.27[b]	2.22[b]	2.27[b]	2.21[b]
Tallow							
Starter (0–4 wk)	BW gain, g Feed/ gain	717[ab]	744	733	749	689	717
		1.81[b]	1.70[b]	170[b]	1.67[b]	1.76[b]	1.59[b]
Final (0–8 wk) Feed/gain	BW gain, g	2,010[b]	2,037	2,078	2,096	1,974	2,020
		2.34[b]	2.28[b]	2.33[b]	2.25[b]	2.36[b]	2.29[b]

1 Each value represents mean of 36 chicks
a-c Means in the same row bearing different superscripts are significantly different (P<0.05).

Fermented or ensiled root meal (FRM)

Dried products, from roots which have been fermented or ensiled, to detoxify the HCN or to increase their protein content, are other ways of root processing. Data on the substitution of the FRM for cereals in poultry rations is limited. In Nigeria, Pido *et al.* (1979) replaced FRM (lafunized roots) for maize at the rates of 0, 25.0, 37.5 and 50% of broiler rations. Bird body weight at 9 weeks was similar for all treatments, whereas, feed conversion ratios slightly increasing as the FRM levels increased. In this study groundnut meal was used as the cassava supplementary protein source and fish meal was fixed at 8% of the diets.

More recently, Khajarern *et al*. (1982) added dried layer manure to fresh cassava chips in the proportion of 1:9, on a dry basis, prior to ensiling the mixture for 24 days. The FRM, containing 5.5% crude protein, was then used to replace; cereals (maize + rice products); 10, 20, 30, 40% cassava; or 50% of a layer diet containing 10% fish meal. The feeds were fed for 270—days egg production and showed that the FRM could successfully replace cereals or cassava in the layer diets. However, a slight reduction in hen-day production and feed conversion was noticed when the FRM inclusion levels were higher than 40% of the ration. This should be expected since the diets were fed in mash form. The initially conclusions are that the FRM can successfully be substituted for other conventional energy sources in poultry feeding, at up to 50% of the ration, providing that the supplementation and form of the feed was similar to that used for cassava root meal. However the economical value of this feed processing method needs to be carefully assessed.

Cassava leaf meal

Limited data on cassava leaf (CLM) and foliage meal (CFM) indicate that these products might be used, at low levels, as pigmenting agents, or, at higher levels, as partial substitutes for the conventional protein sources in poultry rations. Data in Table 3 indicates that the CLM could be included at up to 20% in broiler rations whereas the inclusion levels of CFM were slightly lower. This is natural as CFM contains higher level of crude fibre than CLM. For replacement pullets, the maximum possible inclusion level was 16.5% of pelleted rations, whereas with layers, where it was used as carotenoid source, a maximum level of 5% is recommended (Khajarern *et al*., 1980). The limiting nutritional factors with CLM and CFM are the HCN content, its low energy, bulkiness and possibly their tannin content (Ravindran *et al*., 1986). Normal supplementation of high CLM and CFM inclusion rations are 0.15 to 0.25% methionine and 3.0% fat.

CONCLUSIONS AND RECOMMENDATIONS

It can be concluded from the available evidence that cassava products in various forms, root meal, fermented roots, leaf and foliage meals can successfully be used as substitutes for the conventional feedstuffs in poultry rations, provided that the high cassava-based rations are duly balanced for all nutrients, properly supplemented to correct nutritional problems and are fed in the appropriate forms to assure an adequate feed intake. The following are the key considerations to be taken into account in the incorporation of cassava in the animal diets.

a. It is important to correctly balance cassava-based diets for all nutrient to appropriately satisfy the needs of each class of poultry, plane of nutrition, production intensity, climatic condition and physical nature of diets.

b. HCN depresses chick performance and feed intake due to palatability problems. Care should be taken to use the products with the lowest possible HCN content and to supplement the diets with an adequate amount of methionine, sulphur containing amino acids and nutritional factors supporting methionine and sulphur metabolism.

c. Physical properties of cassava-based diets are important factors limiting feed intake. Thus cassava-based diets should be fed to poultry in pellet forms or after the addition of fat or molasses to eliminate dust and improve texture. Added fat may also be important in increasing the supply of available energy and essential fatty acids needed for normal egg size.

d. Carotenoid substances are needed for the provision of normal egg yolk and broiler skin pigments. They should thus be adequately supplemented preferably by CLM or CFM.

e. It is not possible to define precisely what are the optimum levels of inclusion of cassava products in poultry rations due to inaccuracies in definition of product types and test conditions in the available reports. However, they should be somewhere below the maximum possible inclusion levels given in Table 3. with broilers tending to be able to accept higher cassava levels in their diets than layers. One should take advantage of the maximum economic gains obtained by the complimentary responses of chickens fed diets containing the partially substituting levels of cassava products. Such a substitution also offers opportunities of avoiding the unnecessary supplementation of diets with the expensive imported feed ingredients such as amino acids and carotenoid substances.

Bibliography

Adegbola, A.A. 1977. Methionine as an additive to cassava-based diets. In Mestel, B. and Graham, M. eds., *Cassava as Animal Feed.* Proceedings of a workshop held at the University of Guelph, 18–20 April, 1977. Ottawa, International Development Research Centre, IDRC-095e, 9–17.

Agudu, E.W. and Thomas, O.P. 1982. Available carbohydrate in cassava meal determined by chick bioassay. *Poult.Sci.* 61: 1131–1136.

Chou, K.C. and Muller, Z. 1972. Complete substitution of maize by tapioca in broiler rations. In *Australasian poultry science convention,* Auckland 1972: Proceedings. New Zealand, World Poultry Science Association, 149–160.

Christensen, A.C., Knight, A.D. and Rauscher, G.F. 1977. An evaluation of cassava root meal as energy source for broiler chicks. *Turrialba* 27: 147–149.

Devendra, C. 1977. Cassava as a feed source for ruminants. In Nestel, B., and Graham II. eds., *Cassava as Animal Feed.* Proceedings of a workshop held at the University of Guelph, 18–20 April, 1977. Ottawa, International Development Research Centre, IDRC-095e, 107-119.

Enriquez, F.Q. and Ross, E. 1967. The value of cassava root meal for chicks. *Poult. Sci.* 46: 622–626.

Enriquez, F.Q. and Ross, E. 1972. Cassava root meal in grower and layer diets. *Poult. Sci.* 51: 228– 232.

Eshiett, N. and Ademosun, A.A. 1976. Cassava for poultry. *Progress report on the use of cassava as animal feed in Nigeria*. IDRC, Ottawa.

Fetuga, S.L. and Oluyemi, J.A. 1976. The metabolizable energy of some tropical tuber meals for chicks. *Poult. Sci.* 55: 868–873.

Gomez, G. Santos, J. and Valdi vieso, M. 1984. Evaluation of methionine supplementation to diets containing cassava meal for swine. *J. Anim. Sci.* 58: 812–820.

Gomez, G., Tellez, G. and Caicedo, J. 1987. Effects of the addition of vegetable oil or animal tallow to broiler diets containing cassava root meal. *Poult. Sci.* 56: 725–731.

Hamid, K. and Jalaludin, S. 1972. The utilization of tapioca in rations for laying poultry. *Mal. Agric. Res.* 1: 48–53.

Hutagalung, R.I. 1977. Additives other than methionine. In Mestel, B. and Graham, M. eds., *Cassava as Animal Feed.* Proceedings of a workshop held at the University of Guelph, 18–20 April, 1977. Ottawa, International Development Research Centre, IDRC-095e, 18–32.

Hutagalung, R.I., Jayaludin, S. and Chang, C.C. 1974. Evaluation of agricultural products and by-products as animal feeds. II. Effect of levels of dietary cassava (tapioca) leaf meal and root on prefermance, digestibility and body composition of broilers. *Mal. Agr. Res.* 3: 49– 59.

Khajarern, S., Hutanuwatr, N., Khajarern, J., Kipanit, N., Phalaraksh, R. and Terapuntuwat, S. 1979. *The improvement of nutritive and economic value of cassava root products.* 1979 Annual Report to IDRC, Ottawa, Canada. Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand.

Khajarern, S., Hutanuwatr, N., Khajarern, J., Kitpanit, N., Phalaraksh, R. and Terapuntuwat, S. 1980. *The improvement of nutritive and economic value of cassava root products.* 1979 Annual Report to IDRC, Ottawa, Canada. Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand.

Khajarern, S., Hutanuwatr, N., Khajarern, J., Kitpanit, N., Phalaraksh, R. and Terapuntuwat, S. 1982. *The improvement of nutritive and economic value of cassava root products*. 1980 Annual Report to IDRC, Ottawa, Canada. Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand.

Maust, L.R., Scott, M.L. and Pond, W.G. 1972. The metabolizable energy of rice bran, cassava flour, and blackeye cowpeas for growing chickens. *Poult. Sci.* 51: 1397– 1401.

McMillan, A.M. and Dudley, F.G. 1941. Potato meal, tapioca meal and town waste in chicken rations, Harper Adams Utility. *Poult. J.* 26: 191–194.

Montilla, J.J., Garcia, I.A. and Reveron, A.E. 1973. Valor pigmentante de diversas harinas verdes agregadas a las raciones para pollos de engorde y su efecto sobre el incremento de peso. *Cienc. Vet.* (Maracay), 2: 285.

Montilla, J.J., Vargas, E. and Montaldo, A. 1976. Efecto de varios niveles de harina de follaje de yuca en raciones para pollos de engorde. *Rev. Fac. Agric. Univ. Centr. Venez.* 24: 53.

Muller, Z., Chou, X.C. and Nah, X.C. 1974. Cassava as a total for cereals in livestock and poultry rations. *World Animal Rev.* 12: 19– 24.

Muller, Z., Chou, X.C. and Nah, X.C. 1975. *Cassava as a total substitute for cereals in livestock and poultry rations.* Proceedings of the 1974 Tropical Products Institute Conference, 1–5 April, 85–95.

Olson, D.W., Sunde, M.L. and Bird, H.R. 1969a. Amino acid supplementation of mandioca meal in chick diets. *Poult. Sci.* 481: 1– 949–1953.

Olson, D.W., Sunde, M.L. and Bird, H.R. 1969b. The metabolizable content and feeding value of mandioca meal in diets for chicks. *Poult. Sci.* 48: 1445–1452.

Pido, P.P., Ddeyanju, S.A. and Adegbola, A.A. 1979. The effect of graded levels of fermented cassava meal on broilers. *Poult. Sci.* 58: 427–431.

Rajaguru, A.S.B. and Ravindran, V. 1983. Energy evaluation of selected poultry feed ingredients. *Proc. Sri Lanka Assoc. Advt. Sci.* 39: 24 (Abstr.).

Ravindran, V., Kornegay, B.T., Kajaguru, A.S.B., Potter, L.M. and Cherry, J.A. 1986. Cassava leaf meal as a replacement for coconut oil meal in broiler diets. *Poult. Sci.* 65: 1720–1727.

Ross, E. and Enriquez, F.Q. 1969. The nutritive value of cassava leaf meal. *Poult. Sci.* 48: 846–853.

Siriwadene, J.A.d.S. and Rana weera, M.N.P. 1974. Manioc leaf meal in poultry diets. *Ceylon Vet. J.* 22: 52–57.

Stevenson, M.H. and Jackson, M. 1981. The use of cassava meal in broiler diets. Paper presented to the *Progress in the use of cassava as animal feed.* 12th Intnl. Cong. of Nutr. The Town and Country Hotel, Sandiago, California, U.S.A. 16–21, Aug. 1981.

Szylit, O., Durand, M., Borgida, L.P., Atinkpahoun, H., Prieto, F. and Delort-Laval, J. 1977. Raw and steam-pelleted cassava, sweet potato and yam cayenensis as starch sources for ruminant and chicken diets. *Anim. Feed Sci. Technol.* 3: 73–87.

Tobayayong, T. T. 1935. The value of cassava refuse meal in the ration for growing chicks. *Philipp. Agric.* 24: 509.

US. NRC. 1984. *Nutrient require ments of poultry.* 8th revised ed. National Research Council, NAS. Washington, D. C.

Vogt, H. 1966. The use of tapioca meal in poultry rations. *World Poult. Sci. J.* 22: 113–126.

Yoshida, M. 1970. Bioassay proc edure of energy source for poultry feed and estimation of available energy of cassava meal. *J. Agric. Res. Quart.* 5: 44–47.