Pakistan Journal of Nutrition 14 (10): 735-741, 2015
ISSN 1680-5194

Feeding Value of Some Cassava By-Products Meal for Poultry: A Review

S.S. Diarra and A. Devi
School of Agriculture and Food Technology, University of the South Pacific,
Alafua Campus, P.M. Bag Alafua, Samoa

Abstract: Cassava root meal which has been used as good alternative energy source in poultry and pig diets is increasingly becoming an important energy source for feeding the world's human population. There are however, several by-products of cassava harvest ranging from the leaves, peels and pulp which have potential as feed ingredients in poultry rations. Cassava peels and pulps are moderate to high in energy and have been included in diets as replacements for conventional energy sources. Cassava leaves, moderate to good protein contents, have been used as protein supplements. Dietary recommendations of cassava by-products for poultry have varied considerably. The major factors limiting the efficient utilization of these by-products in poultry diets include the high fibre and low energy contents and likely presence of antinutritional factors, mainly hydrocyanic acid (HCN) in the bitter variety of cassava. Several technologies have been used to improve the utilization of cassava by-products by poultry. The following paper reviewed the composition of some cassava by-products (leaves, peels and pulp), their recommendations for inclusion in poultry diets and processing methods to maximize their utilization by poultry. It was concluded that efficient use of cassava by-products will reduce feed cost of poultry production and provide additional source of income to cassava farmers and processors.

Key words: Conventional ingredients, cassava by-products, dietary recommendations, processing, poultry performance

INTRODUCTION

The high nutritive value, short cycle and relative cheap cost of production, make poultry products the ideal animal protein source for feeding the world's human population. However, high feed cost remains a major impediment to efficient poultry production. Many traditional ingredients used in poultry diets are forecast to be in short supply mainly as a result of the increase in human population and unfavourable climatic conditions (Cribb, 2010). The growing demand for traditional energy and protein feed ingredients as food by the ever-growing world's human population and other industrial uses has increased research interest in alternative cheaper ingredients for poultry feeding.

Cassava, manioc (*Manihot esculenta*), a root crop cultivated mainly in tropical and sub-tropical regions of the world, tolerant to poor soils, diseases and drought, can yield between 25 to 60 tons/ha (Chauynarong *et al*., 2009). The world production of cassava is estimated at more than 230 million metric tones annually (FAOSTAT, 2011) with Nigeria, Brazil, Thailand, Vietnam, Indonesia and DR Congo being the largest producers (FAO, 2008; FAOSTAT, 2011; Khempaka *et al*., 2014). Cassava is reported to be the world's third largest source of carbohydrates for human consumption (Fauquet and Fargette, 1990) which forms an important component in the diet of over 800 million people around the world (FAO, 2008).

Although cassava root meal has been fed to poultry as a major source of energy with success (Salami, 2000; Tewe and Bokanga, 2001; Saparattananan *et al*., 2005), the increased demand of this crop for food and industrial uses such as starch and flour production will reduce its future availability for poultry feeding at economic prices. However, during growing and processing of cassava for food or industrial uses several by-products ensue, which have potential as feed ingredients in poultry diets. This paper reviewed the composition of selected by-products of the cassava crop, their dietary recommendations and factors limiting their efficient utilization by poultry. Some feed technologies used to enhance the utilization of these by-products by poultry are also highlighted.

Nutritive composition and anti-nutritive properties of selected cassava by-products

Cassava peel meal (CPM): During cassava processing for food a major by-product is cassava peel usually with small discarded tubers in various proportions. Cassava peel which accounts for 10-13% of tuber weight (Oladunjoye *et al*., 2010) is readily available in countries where cassava is cultivated and processed into food for human consumption. In areas where cassava is a staple energy source, this product may accumulate and often pose disposal problems. The composition of CPM depends on several factors including variety, stage of maturity and the proportions of peels and tubers in the

Corresponding Author: S.S. Diarra, University of the South Pacific, School of Agriculture and Food Technology, Alafua Campus, P.M. Bag Alafua, Samoa

mixture. Cassava peel meal is reported to contain between 3.1-5% (Tewe and Kasali, 1986; Babatunde, 2013) and 9-12% (Babatunde, 2013; Oladunjoye *et al*., 2010) crude protein and crude fibre, respectively. The high fibre, low energy and low protein contents relative to maize and the presence of HCN in the bitter variety of cassava are the major constraints to the effective utilization of CPM by poultry. Fresh cassava peels can also spoil rapidly on account of the high moisture content and need to be processed immediately. However, large amounts of sweet cassava, low in HCN, are now planted throughout the world for human consumption.

Cassava pulp (CP): Cassava pulp is a solid by-product of starch production from cassava root. During starch production, CP yields from 10-15% of the root (Khempaka *et al*., 2014) which is a readily available material in major starch producing countries. Cassava pulp is rich in starch ranging from about 54-70% (Khempaka *et al*., 2009; Khempaka *et al*., 2014). The pulp is reported to contain between 1.7-2.8%, 1.6-2.0%, 13.6-27.8 and 0.1% ash, crude protein, crude fibre and ether extract respectively (Khempaka *et al*., 2009; Khempaka *et al*., 2014). The fibre of CP exists mainly as insoluble fibre. Suksombat *et al*. (2007) reported 36.7% neutral detergent fibre, 9.8% acid detergent fibre and 3.9% acid detergent lignin in CP. Kosoom *et al*. (2009) however, reported differences in the composition of cassava pulp among starch processing plants. The high fibre and extremely low protein contents, bulkiness and dustiness are the main factors limiting the inclusion of CP in poultry rations.

Cassava leaf meal (CLM): Cassava leaf is a by-product of cassava plant at root harvest but may also be obtained from defoliation during plant growth. Several factors including the cultivar (Ahmad, 1973; Gomez and Valdivieso, 1985), age of plant, plant density, harvesting technique, soil fertility status (Ravindran and Rajaguru, 1988) and frequency of harvesting (Normanha, 1962; Rogers and Milner, 1963; Eggum, 1970; Ravindran and Rajaguru, 1988; Ravindran, 1991; Wobeto *et al*., 2006) have been reported to affect the yield and composition of cassava leaf. Dry matter yields of 1.8 t/ha (Gomez and Valdivieso, 1985) and 4.64 t/ha (Ravindran and Ravindran, 1988) have been recorded at root harvest. Harvesting leaves during the growing period was found to increase DM yield although this may reduce root yield (Dahniya *et al*., 1981; Ravindran and Ravindran, 1988). With adequate irrigation and fertilization, however, cassava plants can withstand defoliation of 60-75 days interval for several years (Montaldo, 1977).

Crude protein contents of 16.7-39.9% have been reported in cassava leaves (Rogers and Milner, 1963; Allen, 1984; Gomez *et al*., 1985; Ravindran *et al*., 1987; Ravindran, 1995; Bui and Ly, 2001; Nguyen, 2012). According to Eggum (1970) 85% of cassava leaf protein exists as true protein. Phuc and Lindberg (2001) reported that the protein of CLM is comparable with alfalfa and soybean meals in terms of essential amino acids. With the exception of methionine, the essential amino acid value of CLM exceeds those of FAO reference protein (Lancaster and Brooks, 1983). Yeoh and Chew (1976) observed that the essential amino acid content of CLM protein is similar to that of the hen's egg and greater than that of oat, rice grain and soybean. The methionine of CLM however, has low biological value ranging from 49 to 57% (Ravindran, 1995) calling for methionine supplementation of diets based on this by-product. Ravindran (1991) analyzed CLM to contain 4.8-29 and 5.7-12.5% crude fibre and total ash respectively. Cassava leaves are good sources of vitamins and xanthophylls, a substance that gives the skin or egg yolk the deep yellow colour. Like cassava pulp, the high fibre content and presence of HCN may limit the efficient utilization of CLM in poultry diets. Ravindran *et al*. (1986) reported 84mg/kg HCN in cassava leaf. The same factors affecting the nutrient content such as genetic, edaphic, physiological and climatic have all been reported to affect the HCN content of the leaves (Gomez and Valdivieso, 1985; Pham *et al*., 2010).

Another factor limiting the utilization of cassava by-products in poultry feeding is their relatively low dry matter content. The composition of some cassava by-products in selected constituents and the amino acid profile of cassava leaf meal are summarized in Table 1 and 2, respectively.

Recommendations of cassava by-products in poultry diets

Broilers: Recommendations of CLM in broiler diets vary within wide ranges. Ravindran *et al*. (1986) observed that broiler performance was sustained up to 15% dietary CLM. In another study Ravindran (1991) observed that above 5% dietary CLM growth performance was not affected but feed intake and feed: gain were increased. Broiler growth was reported to be depressed above 5% dietary CLM (Ross and Enriquez, 1969; Iheukwumere *et al*., 2008) but addition of 0.15 or 0.3% methionine and 3% corn oil was found to correct this growth depression (Ross and Enriquez, 1969) confirming that energy and methionine are the major factors limiting the utilization of CLM in poultry diets. Methionine is a methyl donor as well as a source of labile sulphur. The roles of methyl in tannin detoxification and sulphur in cyanide detoxification (Ravindran, 1991) may further explain the improvement in performance with methionine supplementation of diets based on cassava products. Feeding up to 20% CLM in pelleted broiler diets did not affect performance (Montilla, 1977). The maintained performance may be

Table 1: Composition of cassava peel, pulp and leaf for selected constituents (g/kg)

	Constituents				
By-products	Crude protein	Crude fibre	ME (Kcal/kg)	Hydrocyanic acid	References
Peels	31-52	39-123	2562	0.05	Tewe and Kasali (1986), Iheukwumere *et al*. (2008), Oladunjoye *et al*. (2010), Babatunde (2013)
Dried pulp	20.2	146		0.003	Khempaka *et al*. (2014)
Fermented pulp	117-176	106-171	2.049	0.0009	Chumpawadee and Soychuta (2009), Huu and Khammeng (2014), Khempaka *et al*. (2014)
Leaves	210-390	200-219	1.603		Muller *et al*. (1974), Devendra (1977), Ravindran (1992), Akinfala *et al*. (2002), Kanto and Juttupornpong (2005), Nwokoro and Ekhosuehi (2005)

Table 2: Amino acid composition of cassava leaf meal (g/16 g N)

Amino acids	Dry leaves[a]	Dry leaves[b]	Ensiled leaves[b]	Soybean meal[b]
Arginine	5.3	5.9	5.6	7.5
Histidine	2.3	1.9	1.7	2.5
Isoleucine	4.5	4.4	4.2	4.2
Leucine	8.2	8	8.3	7.6
Lysine	5.9	5.6	5.4	5.3
Methionine	1.9	1.5	1.2	1.1
Phenylalanine	5.4	5.7	5.6	5.6
Threonine	4.4	4	3.9	3.5
Tyrosine	-	4	4.4	3.7
Valine	5.6	5.3	5.3	4.7
Alanine	-	5.7	6.4	4.3
Glycine	-	4.1	4.1	3.6

References: [a]Eggum (1970) and [b]Phuc (2000)

due to improved fibre digestibility through changes in starch structure by the heat of pelleting.

Cassava peel meal (CPM) has been used as energy source in poultry diets with varying results. Inclusion of up to 10% dietary CPM significantly reduced feed cost without adverse effect on growth or carcass characteristics of broiler chickens (Babatunde, 2013). Elanchezhian *et al*. (1999) found that 5% dietary CPM increased live weight gain and feed consumption with no adverse effects on blood composition and dressing percent in layer strain male chicks. Tewe (1983) and Odunsi *et al*. (2001) reported reduced feed intake and depressed growth in both starter and finishing broilers when 30% dietary maize was replaced with CPM.

Dietary inclusion of 16% fermented cassava pulp (CP) with *Aspergillus oryzae* did not affect growth, nutrient digestibility, carcass quality or blood biochemistry of broiler chickens (Khempaka *et al*., 2014). Above this level of inclusion, the authors observed a reduction in growth which they attributed to the physical capacity limit of the gastro-intestinal tract to accommodate enough feed to meet nutrient requirements. In another study, Khempaka *et al*. (2009) observed that dried CP can only be used at 4-8% of the diet of broiler chickens. The authors observed an ameliorative effect of microbial fermentation on protein quality of the product. This improved protein quality and possible changes of the starch structure during fermentation may be the reasons for better performance of birds on fermented CP.

In addition to feed cost reduction dietary inclusion of cassava by-products has been found to be beneficial in terms of birds' health and carcass quality. Broilers fed diets containing cassava products were found to exhibit better health status and required less antibiotic compared to those fed maize based diets (Saentaweesuk *et al*., 2000; Tathawan *et al*., 2002) probably as a result of reduced gut colonization by *E. coli* observed by Promthong *et al*. (2005). Feeding of CP was also found to reduce abdominal fat in broiler chickens (Khempaka *et al*., 2009) thus, improve carcass quality probably through inhibition of fat synthesis on high fibre diets.

Layers: Layer strains appear to tolerate more cassava by-products in the diet mainly because of their lower energy requirement compared to meat type chickens. In a study with laying hens, Obioha *et al*. (1984) observed that 20% dietary CPM maintained performance in terms of egg production, egg weight and feed conversion ratio compared to the control diet based on maize. Replacement of 27% dietary maize with CPM did not depress feed intake, egg production but feed cost per unit egg was reduced (Tewe and Egbunike, 1992). Salami (2000) reported that replacing 50% dietary maize with parboiled CPM optimised egg production with good economic return. According to Oladunjoye *et al*. (2010) replacement of dietary maize with 50% sun-dried and 70% lye treated CPM did not affect egg performance and blood characteristics of laying hens.

Cassava leaf meal has been included in laying hens diets with satisfactory results. Inclusion of 10% CLM in layer diets did not have adverse effects on egg production, egg weight and feed efficiency (Ross and Enriquez, 1969). These authors also observed that increasing dietary CLM up to 20% with added methionine and fat maintained egg production comparable to a corn-soybean diet. Where yellow maize is not readily available, an additional advantage of the use of CLM in layer diet is the presence of xanthophylls which produces yellow coloured yolk and reduces the need of supplementing diets with commercial colourings especially where yellow coloured yolk are in demand. Recommendations of cassava leaf, peel and pulp meals in poultry diets are summarized in Table 3.

Feed technologies for improving the utilization of cassava by-product meals by poultry: The high moisture, high fibre and low energy contents of cassava by-products (peel, pulp and leaves) and the presence of

Table 3: Recommendations of selected cassava by-products in poultry diets

By-product	Method of processing	Broilers (Recommendations)	Layers (Recommendations)	References
Cassava leaf	Sun-drying	5% of diet		Iheukwumere *et al*. (2008)
		10% of cotton seed meal		Wyllie and Chamanga (1979)
		15% of coconut meal	-	Ravindran *et al*. (1986)
		16.5% of diet		Khajarern *et al*. (1980)
	Forced air dried	15% of diet	-	Wyllie and Chamanga (1979)
	With blood meal at 1.5: 1	50% of soybean meal		Adeyemi *et al*. (2012)
	Addition of 0.3% methionine and 3% corn oil	-	20% of diet	Ross and Enriquez (1969)
	Pelleting	20% of diet	-	Montilla (1977)
Cassava peel	Sun-dried	50% of maize	-	Obiokaonu and Udedibie (2006); Oladunjoye *et al*. (2010)
		-	20% of diet	Obioha *et al*. (1984)
		-	50% of maize	Salami (2000)
			100% of maize	Khajarern and Khajarern (1986); Saparattananan *et al*. (2005)
		15% of diet	-	Agunbiade *et al*. (2002), Salami *et al*. (2003)
	Retting	-	75% of maize	Salami and Odunsi (2003)
	Oven-dried	10% of diet	-	Babatunde (2013)
Cassava pulp	Sun-dried	4-8% of diet	-	Khempaka *et al*. (2009)
	Fermented	16% of diet	-	Khempaka *et al*. (2014)

HCN limit their efficient utilization for poultry feeding. Several technologies have been used to improve the nutritive value of these by-products for poultry.

Sun-drying: Cyanide, a highly heat labile substance, seems to be the major anti-nutritional factor in cassava products which has been reported to be reduced below toxic levels by sun-drying. Sun-drying may be the method of choice in tropical countries as it reduces HCN, below toxic levels without noticeable effect on the nutritional quality. Sun-drying also has the advantage of saving cost of energy and equipment both of which may be limiting in small scale farming systems. Gomez and Valdivieso (1985) and Ravindran (1991) reported a 90% reduction of HCN in sun-dried cassava leaves. According to Ravindran *et al*. (1987) once the moisture content is below 12% dried cassava leaves can preserve well with little influence on the crude protein content. Khempaka *et al*. (2014) also observed that sun-drying reduced HCN content of cassava pulp and improved its nutritive value.

Boiling: Thermal processing is known to be an effective method of eliminating most antinutritional factors (Visitpanich *et al*., 1985). Boiling of cassava peels and leaves before feeding to poultry and pigs is a common practice among farmers. Excessive heat application however, may have adverse effect on the nutritional quality of the product. Eggum (1970) observed that boiling may reduce amino acid availability from cassava leaves. Mastering boiling temperature and duration is therefore required for preservation of optimum nutritive quality but this may not be practicable under small scale systems.

Ensiling/fermentation: Ensiling has been found to be an efficient method of improving the utilization of cassava based diets through reduced concentration of HCN and improved digestibility. Nguyen (2012) reported up to 80.6% reduction of HCN in cassava leaves after 90 days of ensiling. Phuc *et al*. (2000) also observed that ensiling reduced the HCN content of cassava leaves by 62%. Van Man and Wiktorsson (2002) ensiled cassava leaves and found a HCN reduction of 68 and 76% after two and four months storage respectively suggesting that HCN reduction is a function of storage length of silage. Ravindran *et al*. (1987) also observed a decline in the HCN content of cassava leaves during storage. These authors however, reported a gradual reduction of the crude protein content with increasing storage length. In a feeding trial using cassava leaves, Hong and Lindberg (2007) observed higher coefficients of ileal apparent digestibility of crude protein, crude fibre and neutral detergent fibre in pigs fed diets based on ensiled than raw or cooked leaves.

Muzanila *et al*. (2000) reported a reduction of HCN content of cassava from 400 to 14 and 5.84 mg HCN/kg by solid-state and wet fermentation, respectively. Fermentation of cassava waste with *Aspergillus niger* for three day was reported to increase the biomass protein from 1.6 (w/w) to 7.0% (Manilal *et al*. 1987). Higher crude protein content and improved starch digestibility of CP fermented with *Aspergillus oryzae* was also observed by Khempaka *et al*. (2014). Increased fibre digestibility with increasing dietary fermented CP was reported by Huu and Khammeng (2014). These authors also observed higher crude protein (13.4%) content in CP fermented with yeast (*Saccharomyces cerevisiae*). Chumpawadee and Soychuta (2009) reported 2.52, 16.8 and 17.6% crude protein in non-fermented, naturally fermented and microbial fermented CP, respectively.

Methionine supplementation: As cassava products are deficient in methionine, supplementation of diets with this amino acid has been reported to be a viable method of upgrading diets containing these products for poultry and pigs (Ravindran, 1991). In addition to correcting deficiency in the diets, the need for extra methionine in HCN detoxification has also been reported in poultry and pigs (Ravindran, 1991). However, Adegbola (1977) observed reduction of urinary thiocyanate in rats fed cassava-based diets with additional methionine and suggested that addition of extra methionine for HCN detoxification may not be justified. Gomez *et al*. (1985) also observed that supplementation of high cassava (65%) diets with 0.2 or 0.3% methionine had no benefit in all classes of pigs. Recently, Diarra (2015) reported that addition of methionine and vegetable oil to cassava leaf meal based diets maintained performance of egg-type pullets.

Addition of fat: Addition of dietary fat to compensate for the low energy in cassava by-products has been reported to improve their utilization by poultry. Addition of corn oil (Ross and Enriquez, 1969) was reported to improve performance of broilers fed diets based on CLM suggesting that energy is a factor limiting the utilization of CLM by broilers. On low energy diets, birds significantly increase feed intake to meet energy requirement which consequently reduces absorption of other nutrients. The low heat increment of fat will also be beneficial in combating heat in poultry fed such diets especially in hot tropical cassava producing regions.

Conclusions: Several by-products from cassava crop (peels, leaves and pulp) could be efficiently utilized to reduce cost of poultry feed. The high fibre, high moisture and likely presence of HCN are however, major limitations to their efficient utilization by poultry. Following appropriate processing, the inclusion rates of these by-products could be maximized to further reduce production cost. In addition to cost reduction, efficient utilization of these by-products will solve disposal problems and generate additional income to farmers and processors in cassava producing regions of the world.

REFERENCES

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 at the University of Guelph, 18-20 April 1997. Ottawa, Institute Development Research Centre, IDRC-095e, 9-17.

Adeyemi, O.A., J.A. Adekoya and R.A. Sobayo, 2012. Performance of broiler chickens fed diets containing cassava leaf: blood meal mix as replacement for soybean meal. Revista. Cient. UDO Agric., 12: 212-219.

Agunbiade, J.A., O.A. Adeyemi, O.A. Adepoju and O.A. Lawal, 2002. The use of whole cassava meal and leaf meal in broiler diets. Tropic. J. Anim. Sci., 5: 161-173.

Ahmad, M.I., 1973. Potential fodder and tuber yields of two varieties of tapioca. Malay. Agric. J., 49: 166-174.

Akinfala, E.O., A.O. Aderibigbe and O. Matanmi, 2002. Evaluation of the nutritive value of whole cassava plant as replacement for maize in the starter diets for broiler chicken. Livest. Res. Rur. Dev., 14: 1-6.

Allen, R.D., 1984. Feedstuffs ingredient analysis table. Feedstuffs (USA), 56: 25-30.

Babatunde, B.B., 2013. Effect of feeding cassava wastes on the performance and meat quality of broiler chickens. Malay. J. Anim. Sci., 16: 63-73.

Bui van, C. and L.V. Ly, 2001. Study on the processing and use of cassava tops as animal feed. http://www.mekarn.org/prockk/chinh.htm.

Chauynarong, N., A.V. Elangovan and P.A. Iji, 2009. The potential of cassava products in diets for poultry. World's Poult. Sci. J., 65: 23-35.

Chumpawadee, S. and S. Soychuta, 2009. Nutrient Enrichment of Cassava Starch Industry By-Product Using Rumen Microorganism as Inoculums Source. Pak. J. Nutr., 8: 1380-1382.

Cribb, J., 2010. The coming famine (The global Food Crisis and What We Can Do to Avoid It). CSIRO Publishing.

Dahniya, M.T., C.O. Oputa and S.K. Hahn, 1981. Effects of harvesting frequency on leaf and root yields of cassava. Exp. Agric., 17: 91-95.

Devendra, C., 1977. Cassava as feed source for ruminants. In: Nestel, B. and Graham, H. (Editors). 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.

Diarra, S.S., 2015. Utilisation of cassava products-copra meal based diets supplemented with or without Allzyme SSF by growing pullets. Malay. J. Anim. Sci., 18.

Eggum, O.L., 1970. The protein quality of cassava leaves. Br. J. Nutr., 24: 761-769.

Elanchezhian, N., R. Ravi and M.R. Purushothaman, 1999. Utilization of cassava peel meal as a feed ingredient in broiler ration. Ind. J. Poult. Sci., 34: 255-258.

FAO, 2008. FAOSTAT production database. Food and Agriculture Organization of the United Nation, downloaded from http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor on 11 November 2008.

FAOSTAT, 2011. Food and Agricultural Commodities Production; Available online: http://faostat.fao.org (accessed 31 January, 2013).

Fauquet, C. and D. Fargette, 1990. African cassava mosaic virus: etiology, epidemiology and control. Plant Dis., 74: 404-411.

Gomez, G., J. Santos and M. Valdivieso, 1985. Evaluation of methionine supplementation to diets containing cassava meal for swine. J. Anim. Sci., 58: 812-820.

Gomez, G. and M. Valdivieso, 1985. Cassava foliage: chemical composition, cyanide content and effect of drying on cyanide elimination. J. Sci. Food Agric., 36: 433-441.

Hong, T.T.T. and J.E. Lindberg, 2007. Effect of cooking and fermentation of a pig diet on gut environment and digestibility in growing pigs. J. Livest. Sci., 109: 135-137.

Huu, H.L. and T. Khammeng, 2014. Effect of yeast fermented cassava pulp (FCP) on nutrient digestibility and nitrogen balance of post-weaning pigs. Livest. Res. Rur. Dev. 26 Article #149. Retrieved February 1, 2015, from http://www.lrrd.org/lrrd26/8/huu26149.htm.

Iheukwumere, F.C., E.C. Ndubuisi, E.A. Mazi and M.U. Onyekwere, 2008. Performance, nutrient utilization and organ characteristics of broilers fed cassava leaf meal (M*anihot esculenta* Crantz). Pak. J. Nutr., 7: 13-16.

Kanto, U. and S. Juttupornpong, 2005. Advantages of cassava in animal rations. Cassava in animal nutrition: With reference to Thailand Cassava, 99: 19-50.

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

Khajarern, S. and J. Khajarern, 1986. Utilization of cassava for animal feed. Proceeding of the 24th Kasetsart University, Bangkok, Thailand, pp: 64-72. (in Thai).

Khempaka, S., W. Molee and M. Guillaume, 2009. Dried cassava pulp as an alternative feedstuff for broilers: Effect on growth performance, carcass traits, digestive organs and nutrient digestibility. J. Appl. Poult. Res., 18: 487-493.

Khempaka, S., R. Thongkratok, S. Okrathok and W. Molee, 2014. An evaluation of cassava pulp feedstuff fermented with *A. oryzae*, on growth performance, nutrient digestibility and carcass quality of broilers. J. Poult. Sci., 51: 71-79.

Kosoom, W., N. Charoenwattanasakun, Y. Ruangpanit, S. Rattanatabtimtong and S. Attamangkune, 2009. Physical, chemical and biological properties of cassava pulp. In: the 47th Kasetsart University Annual Conference, Kasesart, 17-20 March, 2009. Subject: Animals 2009 pp: 2117-2124.

Lancaster, P.A. and J.E. Brooks, 1983. Cassava leaves as human food. Econ. Bot., 37: 331-348.

Manilal, V.B., C.S. Narayanan and C. Balagopalan, 1987. Amyloglucosidase and cellulase activity of *Aspergillus niger* in cassava starch factory wastes. Proceedings of Tropical Tuber Crops Production and Utilization. Indian Society for root crops, CTCRI, Trivandrum, India, 211-213.

Montaldo, A., 1977. Whole plant utilization of cassava for animal feed. In: B. Nestel and M. Graham (Editors). Cassava as Animal Feed. IDRC-095e International Research Development Centre, Ottawa, pp: 95-106.

Montilla, J.J., 1977. Cassava in the nutrition of broilers. Cassava as Animal Feed, 43-50.

Muller, Z., X.C. Chou and X.C. Nah, 1974. Cassava as a total of cereals in livestock and poultry rations. World Anim. Rev., 12: 19-24.

Muzanila, Y.C., J.G. Brennan and R.D. King, 2000. Residual cyanogens, chemical composition and aflatoxins in cassava flour from Tanzanian villages. Food Chem., 70: 45-49.

Nguyen, T.H.L., 2012. Evaluation of local protein sources for growing pigs in Central Vietnam. PhD thesis, Wageningen University, Wageningen, the Netherlands. 155 pages, ISBN 978-94-6173-283-5.

Normanha, E.S., 1962. Meal of stalks and leaves of cassava. Agronom. Venez, 14: 16-19.

Nwokoro, S. and E. Ekhosuehi, 2005. Effect of replacement of maize with cassava peel in cockerel diets on performance and carcass characteristics. Tropic. Anim. Hlth. Prod., 37: 495-501.

Obioha, F.C., G.O. Azubuike, L.S.O. Ene, H.E. Okereke and O.O. Okoli, 1984. The effect of partial replacement of maize with cassava peel on layer performance. Nutr. Report Int., 30: 1423-1429.

Obiokaonu, H.O. and A.B.I. Udedibie, 2006. Comparative evaluation of sun-dried and ensiled cassava peel meals as substitute for maize in broiler starter diets. Int. J. Agric. Rur. Dev., 7: 52-55.

Odunsi, A.A., A.A. Onifade and S.O. Oyewole, 2001. Utilization of cassava peel meals with or without sheabutter fat in diets of egg-type chickens. Ind. J. Anim. Sci., 20: 31-36.

Oladunjoye, I.O., O. Ojebiyi and O.A. Amao, 2010. Ffect of feeding processed cassava (*manihot esculenta crantz*) peel meal based diet on the performance characteristics, egg quality and blood profile of laying chicken. Agric. Tropic. Subtropic, 43: 119-126.

Pham, K.T., N. Le Duc, W.H. Hendriks, C.M.C. van der Peet-Schwering and M.W.A. Verstegen, 2010. Effect of dietary lysine supplement on the performance of Mong Cai sows and their piglets. Asian-Aust. J. Anim. Sci., 23: 385-395.

Phuc, B.H.N., B. Ogle and J.E. Lindberg, 2000. Effect of replacing soybean protein with cassava leaf protein in cassava root meals based diets for growing pigs on digestibility and N retention. Anim. Feed Sci. Technol., 83: 223-235.

Phuc, B.H.N. and J.E. Lindberg, 2001. Ileal digestibility of amino acids in growing pigs fed cassava root meal diet with inclusion of cassava leaves, lucaena leaves and groundnut foliage. Anim. Sci., 72: 511-517.

Promthong, S., U. Kanto, C. Tirawattanawanich, S. Tongyal, S. Isariyodom, K. Markvichitr and A. Engkagul, 2005. Comparison of nutrient composition and carbohydrate fractions of corn, cassava chips and cassava pellet ingredients: Animals. Proceedings of 43rd Kasetsart University Annual Conference, Thailand.

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

Ravindran, V., E.T. Kornegay and A.B.S. Rajaguru, 1987. Influence of processing methods and storage time on the cyanide potential of cassava leaf meal. Anim. Feed Sci. Technol., 17: 227-234.

Ravindran, V. and A.S.B. Rajaguru, 1988. Effect of stem pruning on cassava root yield and leaf growth. Sri Lankan J. Agric. Sci., 25: 32-37.

Ravindran, V. and G. Ravindran, 1988. Changes in the nutritional composition of cassava (Manihot esculenta Crantz) leaves during maturity. Food Chem., 29: 299-309.

Ravindran, V., 1991. Preparation of cassava leaf product and their use as animal feeds. Proceedings of the FAO expert consultation CIAT, Cali, Columbia, 21-25, pp: 81-95.

Ravindran, V., 1992. Preparation of cassava leaf products and their use as animal feeds. Proceedings of roots, tubers, plantains and bananas in animal feeding. FAO, Rome.

Ravindran, V., 1995. Performance of broiler chicks fed sweet potato meal (*Ipomea batatas*) diet. Tropic. Anim. Hlth. Prod., 31: 383-389.

Rogers, D.J. and M. Milner, 1963. Amino acid profile of manioc leaf protein in relation to nutritive value. Econ. Bot., 17: 211-216.

Ross, E. and F.Q. Enriquez, 1969. Nutritive value of cassava leaf meal. Poult. Sci., 48: 846-853.

Saentaweesuk, S., U. Kanto, S. Juttapornpong and P. Harinsut, 2000. Substitute of cassava meal for corn in broiler diets. Proceedings of 38th Kasetsart University Annual Conference: Animal, Veterinary Medicine, Bangkok, Thailand.

Salami, R.I., 2000. Preliminary studies on the use of parboiled cassava peel meal as a substitute for maize in layers' diets. Tropic. Agric., 77: 199-204.

Salami, R.I. and A. Odunsi, 2003. Evaluation of processed cassava peel meals as substitute for maize in the diets of layers. Int. J. Poult. Sci., 2: 112-116.

Salami, R.I., A.L. Ogunmola and O. Akindoye, 2003. Cassava peel processed by different methods as substitute for maize in cockerel starter diets. Proceedings of 28th Annual Conference of Nigerian Society of Animal Production, 16-20 March. Ibadan. pp: 177-179.

Saparattananan, W., U. Kanto, S. Juttupornpong and A. Engkagul, 2005. Utilization of cassava meal and cassava leaf meal in layer diets on egg quality and protein content in egg: Animals. Proceeding of the 43rd Kasetsart University Annual Conference, Bangkok, Thailand.

Suksombat, W., P. Lounglawan and P. Noosen, 2007. Energy and protein evaluation of five feedstuffs used in diet in which cassava pulp as main energy source for lactating dairy cows. Suranaree J. Sci. Technol., 14: 99-107.

Tathawan, S., S. Moonchaisuk, N. Tanasrisutarat, U. Kanto and S. Juttapornpong, 2002. A comparative study of corn and cassava diets both supplemented and unsupplemented with antibiotic on performance and mortality rate of broilers. Proceedings of 40th Kasetsart University Annual Conference, Thailand. (in Thai).

Tewe, O.O., 1983. Thyroid cassava toxicity in animals. In Proc. International workshop on cassava toxicity and thyroid. In: F. Delange, R. Ahluwalia (Editors). Research and Public Health Issues. Ottawa, Canada. IDRC-207e, pp: 114 -118.

Tewe, O.O. and O.B. Kasali, 1986. Effect of cassava peel processing on the performance, nutrient utilization and physiopathology of the African giant rat (*Cricetomy gambianus*, water house). Trop. Agric., (Trinidad), 63: 125-128.

Tewe, O.O. and G.N. Egbunike, 1992. Utilization of cassava in nonruminant livestock feeds. Cassava as livestock feed in Africa. Proceedings of the IITA/ILCA/University of Ibadan workshop on the potential utilization of cassava as livestock feed in Africa. Nigeria, 28-38.

Tewe, O.O. and M. Bokanga, 2001. Research highlights on cassava utilization. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Van Man, N. and H. Wiktorsson, 2002. Effect of molasses on nutritional quality of cassava and gliricidia tops silage. Asian-Aust. J. Anim. Sci., 15: 1294-1299.

Vistipanich, T., E.S. Batterham and B.W. Norton, 1985. Nutritional value of chickpea (*Cicer arietinum*) and pigeonpea (*Cajanus cajan*) meals for growing pigs and rats. II. Effects of autoclaving and alkali treatment. J. Agric. Res., 36: 327-335.

Yeoh, H.H. and M.Y. Chew, 1976. Protein content and amino acid composition of cassava leaf. Phytochem., 15: 1597-1599.

Wobeto, C., A.D. Correa, C.M. de Abreu, C.D. Pato dos Santos and J.R. de Abreu, 2006. Nutrients in the cassava (*manihot esculenta* crantz) leaf meal at three ages of the plant. Ciênc. Tecnol. Aliment, Campinas, 26: 865-869.

Wyllie, D. and P.J. Chamanga, 1979. Cassava leaf meals in broiler diets. Tropic. Anim. Prod., 4: 232-240.