PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 8 (4): 361-367, 2009
ISSN 1680-5194

Nutrient Utilization and Digestibility of Growing Pigs Fed Diets of Different Proportions of Palm Kernel Meal and Brewers Dried Grain

K.U. Amaefule, O.C. Onwudike, S.N. Ibe and S.F. Abasiekong
College of Animal Science and Animal Production, Michael Okpara University of Agriculture,
Umudike, P.M.B. 7267, Umuahia, Abia State, Nigeria

Abstract: Nutrient utilization and digestibility of growing pigs fed diets of different proportions of Palm Kernel Meal (PKM) and Brewers Dried Grain (BDG) in the humid tropics were determined with twelve intact male hybrid (Landrace x Duroc) pigs aged 15 weeks. Their live weights ranged 16.78-19.50 kg (average 18.36 kg). The experimental design was a Completely Randomized Design (CRD). The diets were control, 30% PKM+40% BDG, 35% PKM+35% BDG and 40% PKM+30% BDG for diets I, II, III and IV, respectively. Each diet had three replicates and a male pig per replicate. Locally constructed metabolism cages (107×60×50 cm) were used for the experiment. Measurements were nutrient intake, faecal nutrient output, digestibility coefficient of nutrients, energy utilization, Nitrogen (N) balance and protein utilization. Results showed that growing pigs fed diets of different proportions of PKM and BDG did not significantly ($P<0.05$) differ in digestibility coefficient of CP, protein utilization and N balance while 40% PKM+30% BDG diet significantly ($P<0.05$) increased N intake of growing pigs. The energy utilization indices of pigs fed diets of 35% PKM+35% BDG and 40% PKM+30% BDG were consistently superior to that of pigs fed control diet except ME as percentage of Gross Energy (GE). In conclusion, growing pigs could be fed diets different proportions of PKM and BDG without adverse effect on nutrient utilization and digestibility; however N intake would increase with 40% PKM+30% BDG diet.

Key words: Brewers dried grain, growing pigs, palm kernel meal, nutrient utilization

INTRODUCTION

Pig production in the humid tropics is constrained by seasonal feed deficits and high cost, erratic supply of feed ingredients and competition between humans and pigs for available feed resources (Halimani *et al.*, 2007). However, the use of agro-industrial by-products (AIBPs) is being exploited in pig feeding as a measure for sustainable livestock production and development (Fatufe *et al.*, 2007). Although, some of the AIBPs may be nutritionally inferior to the conventional feedstuffs, Preston and Leng (1987) suggested that livestock systems in developing countries should be matched with available feed resources in a way that aims at economic optimization rather than biological maximization.

Palm Kernel (PKM) and Brewers Dried (BDG) are the 2 AIBPs commonly used in feeding pigs in the Southern of Nigeria. PKM is a by-product of red palm oil industry (Fatufe *et al.*, 2007). It contains about 18-21% crude protein (Olomu, 1995; Agunbiade *et al.*, 1999; Amaefule *et al.*, 2006a) with methionine as the first limiting amino acid (McDonald *et al.*, 1995) and low contents of lysine, histidine and threonine (Jegede *et al.*, 1994). Pigs could be fed 40% PKM (Amaefule *et al.*, 2007) or 50% PKM diet (Ekenyem, 2002) with no adverse effect on feed intake and performance.

Brewers Dried Grain (BDG) is a well known high fibre feed with medium to high protein content (Van Soest and Fox, 1992; Dung, 2001). It contains about 19-25% crude protein, 10-22% crude fibre and Gross Energy (GE) value of about 3030-3170 kcal/kg (Oluponna *et al.*, 2002; Amaefule *et al.*, 2006b, c; Amaefule *et al.*, 2007). BDG from barley constituting 15% of growing pigs diet did not depress growth but lowered nutrient digestibility (Babatunde *et al.*, 1975) while, BDG from malted sorghum and wheat could constitute up to 40 and 35% of the diet of weaned and finisher pigs, respectively.

In an earlier study, Amaefule *et al.* (2006a) had evaluated the growth response of weaner pigs to diets of different proportions and high levels of PKM and BDG in the humid tropics and reported that weaner pigs could be fed diets of 70% PKM+BDG at different proportions with an expectation of inferior feed: gain ratio and protein efficiency ratio, relative to the control (without PKM and BDG) diet. Considering that PKM and BDG have very high Crude Fibre (CF) contents and the effect such high dietary CF and possible interaction among the 2 feedstuffs could have on feed nutrient utilization of growing pigs, this present study became necessary as a follow up with the objective of determining the nutrient utilization and digestibility of growing pigs fed diets of different proportions of Palm Kernel Meal (PKM) and Brewers Dried Grain (BDG).

MATERIALS AND METHODS

The study was conducted at the Piggery Unit of the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Brewers dried grain was obtained from Nigerian Breweries, Aba, Abia State; wheat offal from Calabar Flour mill, palm kernel meal from a company in Aba that uses hydraulic press method for oil extraction from palm kernels and pigs from the University Farm.

Experimental pigs and management: The nutrient utilization and digestibility of growing pigs fed diets of different proportions of palm kernel meal and brewers dried grain were determined with 12 intact male hybrid (Landrace×Duroc) pigs whose live weights ranged from 16.78-19.50 kg (average 18.36 kg) and aged 13 weeks. The pigs were put individually in a metabolism cage (107×60×50 cm) locally designed and constructed with wood for this study. The cage floor was strong metal gauze covered on top with metal wire net to enable separation of urine from faeces and ensure easy and total faecal collection. An aluminum sheet placed underneath the cages served for urine collection by channeling urine through a plastic funnel containing spongy sieve into a plastic container that was properly labeled. The height of the cage from the ground was 60 cm. The feed and water through areas of the cages (each measuring 30×30×27 cm) were fitted with stainless bowls tightly secured to prevent pigs from pouring away feed and water. The metabolism cages were housed inside a pig house with three cages kept in a pen measuring 3.95×2.96 m.

Diets and feeding: Each experimental diet was fed to the pigs at the daily rate of 3.30% of live weight in line with the procedure of Tram and Preston (2004). The diets were milled to pass through a 2 mm sieve, thoroughly mixed to obtain uniform composition and supplemented with 2.0% bone meal. This was to prevent calcium and phosphorus deficiency. Water was provided to the pigs *ad libitum* throughout the experiment.

Experimental design and data collection: The Experimental design was Completely Randomized Design (CRD). There were four treatments; each replicated three times, with one intact male pig constituting a replicate. The pigs were kept in the cages for nine days to acclimatize before experimental feeding, faeces and urine collection began. This also enabled the technical assistants get used to the protocol of the experiment. The pigs were starved for 12 h prior to the experimental feeding to clear the gut of the previous meals, especially as markers were not used. They were also starved for another 12 h at the end of the feeding period to ensure total collection of faeces arising from the diets offered.

Faeces and urine were collected separately on a daily basis every morning (7.30-8.30 am). The faeces were oven dried at 60°C, weighed and put in a labeled plastic bag and stored in a deep freezer. Urine was also collected three times (7.00 am, 12.00 noon and 5.00 pm, local time) daily in a labeled plastic container, with the record of the total weight and volume. About 10% of each day's collection was stored in 10 mL of 10% sulphuric acid to prevent nitrogen losses by evaporation of ammonia and help keep the urine pH below 4. The urine was stored in a deep freezer until required for analysis. At the end of 7 days collection period, faeces from each replicate were mixed, milled and representative samples taken for proximate composition determination. The urine from each replicate was also mixed together and representative samples taken for nitrogen determination.

Chemical and data analyses: Proximate composition of experimental diets, faeces and nitrogen in urine were determined according to the method of AOAC (1990). The Gross Energy (GE) of the diets and faeces were calculated from the proximate components according to the equation of Ewan (1989):

$$GE = 4143 + (56 \times \%\ EE) + (15 \times \%\ CP) - (44 \times \%\ Ash);\ R^2 = 0.98$$

Where:
GE = Gross energy (kcal/g).
EE = Ether extract.
CP = Crude protein (N x 6.25).
Ash = Crude ash.

Dietary GE intake minus the GE of faeces gave Digestible Energy (DE). Metabolizable Energy (ME) intake was calculated as 96% of DE (Farrell, 1979; Agricultural Research Council, 1981; National Research Council (NRC), 1998). The factor used for the correction of ME to nitrogen equilibrium (MEn) was 7.83 kcal/g according to Wu and Ewan (1979). The equations of Close and Menke (1986) were adapted in calculating Biological Value (BV) and Net Protein Utilization (NPU) as follows:

$$BV = \frac{\text{N intake-(Faecal N-FNe)-(Urinary N-UNe)}}{\text{N intake-(Faecal N-FNe)}} \times 100$$

Where:
Fne = Endogenous N losses in faeces.
Une = Endogenous N losses in urine.

$$NPU = BV \times \frac{\text{IN-FN-FNe}}{\text{IN}}$$

Where:
IN = Nitrogen intake.
FN = Faecal nitrogen.

Data obtained were subjected to Analysis of Variance (ANOVA) for a completely randomized design (Steel and Torrie, 1980). The values in percentages were subjected to Arcsine transformation before ANOVA, while differences among treatment means were separated using Duncan's (1955) Multiple Range Test.

RESULTS

Growing pigs fed diets of different proportions of PKM and BDG had significant (P<0.05) differences in DM intake (Table 3). Diet IV (40% PKM+30% BDG) gave the highest DM intake while the control diet (diet I) gave the lowest. However, the higher DM intake of the pigs fed diet IV did not result in higher faecal Dry Matter (DM) but significantly (P<0.05) increased faecal Organic Matter (OM) compared to diets I and III. The growing pigs did not differ in their DM intake as percentage of Body Weight (BW), DM retention, OM intake and OM retention. Diets of different proportions of PKM and BDG significantly (P<0.05) influenced only digestibility coefficient of CP and CF. Diet of equal proportions (35% PKM+35% BDG) of PKM and BDG fed to growing pigs significantly lowered digestibility coefficient of CP relative to the control diet while pigs fed diets of other proportions of PKM and BDG had non-significant (P>0.05) differences in their digestibility coefficients of CP and CF. In addition, the pigs fed control diet had non-significant difference in digestibility coefficient of CF with those fed diets III (35% PKM+35% BDG) and IV (40% PKM+30% BDG). Apart from these two digestibility indices, there were no significant differences among growing pigs fed control and diets of different proportions of PKM and BDG in other digestibility indices measured.

Different proportions of PKM and BDG significantly (P<0.05) influenced GE intake of the growing pigs, with diet III resulting in the highest intake and control diet the lowest. However, the faecal energy of the pigs fed PKM+BDG diets were similar but higher than that of pigs fed control diet as shown in Table 4. Digestible Energy (DE), Metabolizable Energy (ME) and MEn intake of the pigs was of the same pattern with faecal energy output while ME:DE ratio and ME as percentage of GE were not affected by the diets. It could be observed that the DE, ME and Men intake of the pigs increased with the low (8.63-9.76 Mkg^{-1}) energy (PKM + BDG) diets than with the control diet that had a higher energy (11.44 MJ/kg) density.

Diets of different proportions of PKM and BDG significantly (P<0.05) increased Nitrogen (N) intake of the pigs relative to the control diet while the faecal N output did not differ among pigs fed control and 40% PKM + 30% BDG diet (Table 5). Other protein utilization and N balance indices measured were not affected by the experimental diets fed to growing pigs.

Table 1: Composition of diets of different proportions of PKM and BDG fed to growing pigs (as fed basis)

Ingredients	I	II	III	IV
White maize	350.00	0.00	0.00	0.00
Groundnut cake	200.00	100.00	100.00	100.00
Local fish meal	20.00	20.00	20.00	20.00
Palm kernel meal	0.00	300.00	350.00	400.00
Brewers dried grain	0.00	400.00	350.00	300.00
Maize offal	100.00	100.00	100.00	100.00
Wheat offal	190.00	40.00	40.00	40.00
Bone meal	35.00	35.00	35.00	35.00
Vitamin premix*	2.50	2.50	2.50	2.50
NaCl	2.50	2.50	2.50	2.50
Total (kg)	1000.00	1000.00	1000.00	1000.00
Calculated composition				
CP (%)	18.65	21.00	20.85	20.70
ME (MJ/kg)	11.44	8.63	9.61	9.76
CP:ME ratio	1.63	2.43	2.17	2.12
CF (%)	4.34	12.96	12.56	12.16
Lysine (%)	0.56	0.86	0.85	0.84
Methionine (%)	0.28	0.39	0.39	0.39
Ca (%)	1.42	1.42	1.42	1.42
Avail. P (%)	0.59	0.59	0.59	0.59

*Premix supplied Vitamin A 200000 IU, Vit. D_3 400000 IU, Vit. E 8.00 g, Vit. K_3 0.40 g, Vit. B_{12} 0.32 g, Vit. B_2 0.96 g, Vit B_6 0.56 g, Vit. C 2400 mg, Vit. B_{12} 400 mg, Folic acid 0.16 g, Biotin 8.00 mg, Choline 48.00 g, Ca Pantothionate 1.60 g, Mn 16.00 mg, Fe 8.00 mg, Zinc 7.20 g, Copper 0.32 g, Iodine 0.25 mg, Cobalt 36.00 mg, Selenium 16.00 mg, BHT 32.00 g

Table 2: Proximate and energy composition of Palm kernel meal and brewers dried grain fed to growing pigs

Composition*	PKM	BDG
Dry matter (%)	89.70	89.50
Crude protein (%)	20.53	22.49
Ether extract (%)	6.15	6.25
Crude fibre (%)	16.25	21.00
Crude ash (%)	4.30	4.70
Nitrogen free extract (%)	42.47	35.06
Gross energy (MJ/kg)	19.27	19.34

*DM basis. PKM = Palm Kernel Meal; BDG = Brewers Dried Grain

DISCUSSION

The diets of different proportions of PKM and BDG influenced DM intake of the growing pigs probably due to the differences in the CP and CF contents (Table 1) of the diets. This is in consideration of the CP: ME ratio of the diets in relation to the constant supply of lysine and methionine in the PKM+BDG diets. Noblet (1998) had stated that the effect of lowering the dietary CP level (at constant supply of essential amino acids) on voluntary Feed Intake (VFI) is not quite clear and that differences in response could be due to factors such as genotype or sex, nature of ingredients, sub-limiting or excessive levels of some amino acids and environmental conditions. In this study, reduction in the level of BDG in the diets from 40-30% could be attributed to the observed reduction in the CP content of diets III and IV, which could not be compensated by the same increase in the levels of PKM. This is supported by our earlier

Table 3: Nutrient utilization and apparent nutrient digestibility coefficients of growing pigs fed diets of different proportions of PKM and BDG

Nutrient	I	II	III	IV	SEM
Live weight (kg)	16.78	18.50	19.50	18.67	0.87
Dry matter (DM) intake (g)	435.90[d]	439.80[c]	442.30[b]	443.20[a]	0.01
DM intake as % of BW	2.60	2.38	2.27	2.37	-
Faecal DM (g)	89.13[b]	90.29[a]	90.24[a]	89.44[b]	0.28
DM retention	368.93	323.13	355.33	320.57	0.12
Organic matter (OM) intake (g)	448.00	445.00	446.00	447.00	0.01
Faecal OM (g)	77.82[b]	80.56[ab]	78.75[b]	84.00[a]	1.18
OM retention (g)	384.23	337.43	374.97	334.90	0.18
Digestibility coefficients (%)					
Dry matter	83.41	72.30	75.18	72.94	2.62
Organic matter	85.77	75.83	84.07	74.92	3.87
Crude protein	89.21[a]	78.33[ab]	75.49[b]	81.12[ab]	2.85
Crude fibre	70.55[b]	92.79[a]	88.84[ab]	85.34[ab]	5.25
Ether extract	85.59	76.66	83.93	75.22	3.20
Nitrogen free extract	87.26	75.07	80.92	76.48	2.87
Energy (DCe)	86.16	75.00	77.89	76.45	2.57

[a, b, c, d]Means in a row with different superscripts are significantly different (P<0.05). SEM = Standard Error of Mean.
PKM = Palm Kernel Meal; BDG = Brewers Dried Grain

Table 4: Energy utilization of growing pigs fed diets of different proportions of PKM and BDG

Energy (MJ/kg)	I	II	III	IV	SEM
Gross Energy (GE) intake	9.06[d]	12.18[c]	12.47[a]	12.29[b]	0.001
Faecal GE	1.26[b]	3.05[a]	2.76[a]	2.87[a]	0.44
Digestible Energy (DE) intake	7.81[b]	9.14[ab]	9.71[a]	9.33[a]	0.44
Metabolizable Energy (ME) intake	7.49[b]	8.82[ab]	9.32[a]	8.96[a]	0.41
MEn	7.46[b]	8.79[ab]	9.29[a]	8.93[a]	0.41
ME:DE ratio	95.90	96.50	95.98	96.03	-
ME as % of GE	82.71	72.33	74.77	73.40	2.29

[a, b, c, d]Means in a row with different superscripts are significantly different (P<0.05). SEM = Standard Error of Mean.
PKM = Palm Kernel Meal; BDG = Brewers Dried Grain. Men = Metabolizable energy corrected for nitrogen

Table 5: Nitrogen balance and protein utilization of growing pigs fed diets of different proportions of PKM and BDG

Nitrogen Balance (g/d)	I	II	III	IV	SEM
Nitrogen (N) intake	16.23[d]	21.94[b]	21.52[c]	23.02[a]	0.003
Faecal N	1.76[b]	4.78[a]	5.44[a]	4.21[ab]	0.86
Urinary N output	4.66	5.40	4.67	5.04	1.20
Digested N	14.50	17.16	16.09	18.81	0.86
N retention	9.84	11.76	11.42	13.77	1.38
Retention as % of:					
Intake	60.55	53.61	53.04	59.80	6.35
Digested N	68.02	68.81	70.39	73.12	7.06
Biological value (%)	69.04	70.15	72.27	72.99	4.63
Net protein utilization (NPU)	63.09	56.29	56.53	60.75	6.17

[a, b, c, d]Means in a row with different superscripts are significantly different (P<0.05). SEM = Standard Error of Mean.
PKM = Palm Kernel Meal; BDG = Brewers Dried Grain

observation (Amaefule *et al*., 2006b) that diets based on high levels of BDG did not affect apparent digestibility coefficient of CP of growing pigs. The pigs therefore could have increased their VFI that gave rise to higher DM intake. The growing pigs were of the same sex or genotype and were kept under the same environmental condition suggesting that observed differences in DM intake, faecal DM and OM could be attributed to the nature (biochemical characteristics) of PKM, BDG and diets composed of them.

The significant reduction in the digestibility coefficient of CP by the diet of equal proportions (35% PKM+35% BDG) of PKM and BDG could be due to the interaction between PKM and BDG in the diets. Dietary CP digestibility of growing pigs in this study could have been affected by the inclusion levels of PKM and BDG (Stanogias and Pearce, 1985) and consequently by the high dietary fibre in the diets (Noblet and Perez, 1993; NRC, 1998). Although, there is disagreement concerning the influence of dietary fibre on protein digestibility (NRC, 1998), we believe that the increase in the level of fibre in the PKM and BDG diets (Table 1) may have affected protein digestibility since the two feedstuffs, also high fibre sources, contributed significant amounts of protein to the diets (Kennelly and Aherne, 1980). Hansen *et al.* (2007) had explained that fibre diets influenced nitrogen excretion due to N repartitioning from urine to faeces, which invariably affects apparent digestibility coefficient of CP.

Palm Kernel Meal (PKM) and Brewers Dried Grain (BDG) are well known high-fibre feeds (Dung *et al*., 2002) with medium protein contents. According to Souffrant (2001), fibre is a heterogeneous mixture of polysaccharides (structural and non-structural) and lignin that are not digested by endogenous secretions of the digestive tract. Fibre utilization by pigs have been reported to be influenced by the physical and chemical composition of the diet (Myer *et al*., 1975), level of feeding (Cunningham *et al*., 1962), age and weight of animal (Morel *et al*., 2006), adaptation to the fibre diet (Pollman *et al*., 1979) and individual variation among the pigs (King and Taverner, 1975). The digestibility coefficient of CF observed in this study could therefore be attributed to ingredient matrix of the diets, levels of fibre and individual variations among the pigs fed the treatment diets. The growing pigs may have also adapted well to the diets before the study began. NRC (1998) also reported that fibre provides substrate for microbial fermentation in the large intestine, which could have also improved the apparent digestibility coefficient of dietary CF of up to 92.79% for diet II.

The difference in GE intake of pigs fed diets of different proportions of PKM and BDG could be due to the differences in CP, ME and CP: ME ratio of the diets (Table 1). Contrary to the report of Noblet and van Milgen (2004) that daily energy intake remains relatively constant across diets with different energy densities, DE and ME intake of growing pigs increased with the low energy (PKM+BDG) diets when compared to the high energy (control) diet probably due to unknown animal and or environmental factors (Noblet and van Milgen, 2004). Our results are also in contrast to the report of De la Llata *et al.* (2001) that at low energy densities, energy intake of pigs reduces. Although, we assumed that the energy loss in methane, which is 0.4% of DE intake (Noblet *et al*., 1994), is negligible, we got the ME:DE ratio of 96%. This is in line with the report of Noblet (1998) that the ME:DE ratio of complete feeds is relatively constant and equivalent to about 0.96.

The influence of diets of different proportions of PKM and BDG on N intake and faecal N of growing pigs did not follow the pattern of the CP content of the diets. The pigs could have increased N intake (through increase in VFI) to meet their amino acid requirements from the high fibrous PKM+BDG diets. The higher faecal N output of pigs fed PKM+BDG diets is an indication that more N could be released to the environment, especially as there were no improvement in other n utilization indices compared to pigs fed the control diet. Noblet (1998) had suggested that the amount of N intake should be reduced while keeping amino acid supplies adequate for meeting the animal's requirements. We propose that sources of dietary starch (Yin *et al*., 2006); fibre or high inclusion levels of PKM and BDG in the diets did not adversely affect N utilization of the pigs.

The faecal N we obtained in this study are higher than those of Yin *et al.* (2006) with different sources of starch (corn, brown rice, sticky rice or Hi-Maize) while urinary N output compares favourably with the values they obtained. The overall results obtained could be attributed to the biochemical properties of PKM and BDG, level of feeding (Uden and Van Soest, 1982), supplementation of the diets with mineral and vitamin premix (Yin *et al*., 1993) and the individual differences among the pigs. Kidders and Manners (1978) had stated that the digestibility of a particular protein will vary to some extent according to the level of feeding, will be influenced by other components of the diet and may also depend on the age and other characteristic features of the pigs used.

Conclusion: Growing pigs fed diets of different proportions of PKM and BDG did not significantly differ in digestibility coefficient of nutrients, protein utilization and N balance while 40% PKM+30% BDG diet significantly increased N intake of pigs. Growing pigs could therefore be fed diets of any of the different proportions of PKM and BDG without adverse effect on nutrient utilization and digestibility, expecting that N intake would increase with 40% PKM + 30% BDG diet.

REFERENCES

Agunbiade, J.A., J. Wiseman and D.J.A. Cole, 1999. Energy and nutrient use of palm kernels, palm kernel meal and palm kernel oil in diets for growing pigs. Anim. Feed Sci. Technol., 80: 165-181.

Agricultural Research Council, 1981. The Nutrient Requirement of Pigs: Technical Review Ed. Slough, England. Commonwealth Agric. Bureax, 22: 307.

Amaefule, K.U., O.C. Onwudike, S.N. Ibe and S.F. Abasiekong, 2006c. Performance, cost benefit, carcass quality and organ characteristics of pigs fed high graded levels of brewers dried grain diets in the humid tropics. Pak. J. Nutri., 5: 242-247.

Amaefule, K.U., S.F. Abasiekong, O.C. Onwudike and S.N. Ibe, 2007. The effect of feeding graded levels of palm kernel meal diets on performance, carcass quality and organ characteristics of pigs maintained in the humid tropics. Niger Agric. J., 38: 108-116.

Amaefule, K.U., S.N. Ibe, S.F. Abasiekong and O.C. Onwudike, 2006a. Response of weaner pigs to diets of different proportions and high levels of palm kernel meal and brewers dried grain in the humid tropics. Pak. J. Nutri., 5: 461-466.

Amaefule, K.U., S.O. Okechukwu, S.N. Ukachukwu, F.C.Okoye and O.C. Onwudike, 2006b. Digestibility and nutrient utilization of pigs fed graded levels of brewers' dried grain based diets. Livestock Research for Rural Development (LRRD) Vol. 17, Art. No. 5 http://www.cipav.org.co/lrrd18/1/amae18005.htm.

AOAC, 1990. Official Methods of Analysis. Association of Official Analytical Chemists, Washington DC., USA.

Babatunde, G.M., B.L. Fetuga, O. Odumosu and V.A. Oyenuga, 1975. PKM as the major protein concentrate in the tropics. J. Sci. Feed Agric., 26: 1276-1291.

Close, W.H. and K.H. Menke, 1986. Manual in Selected Topics in Animal Nutrition. 3rd Hohenheim Course on Animal Nutrition in the Tropics and Semi-tropics (2nd Ed.), Univ. of Hohenheim, Stuttgart, Germany.

Cunningham, H.M., D.W. friend and J.W.G. Nicholson, 1962. The effect of age, body weight, feed intake and adaptability of pigs on the digestibility and nutrient value of cellulose. Can. J. Anim. Sci., 42: 167-175.

De la Llata, M., S.S. Dritz, M.D. Tokach, R.D. Goddb, J.L. Nelssen and T.M. Loughin, 2001. Effect of dietary fat on growth performance and carcass characteristics of growing-finishing pigs reared in a commercial environment. J. Anim. Sci., 79: 2643-2650.

Duncan, D.B., 1955. Multiple range and multiple f-tests. Biometrics, 11: 1-42.

Dung, N.N.X., 2001. Evaluation of green plants and by-products from the Mekong Delta with emphasis on fibre utilization by pigs. Ph.D Thesis, Swedish Univ. Agric. Sci. Uppsala, Sweden.

Dung, N.N.X., Manh, L.H. and P. Uden, 2002. Tropical fibre sources for pigs-digestibility, digesta retention and estimation of fibre digestibility *in vitro*. Anim. Feed Sci. Technol., 102: 109-124.

Ekenyem, B.U., 2002. The growth responses of weaner pigs fed varying levels of palm kernel cake. Proceedings 27th Annual Conference, Nigerian Society Animam Production (NSAP), March 17-21, Fed. Univ. Technol. Akure, Nigeria, pp: 156-159.

Ewan, R.C., 1989. Predicting the Energy Utilization of Diets and Feed Ingredients by Pigs. In: Energy Metabolism, European Association of Animal Production Bulletin No. 43, Van der Honing, Y. and W.H. Close (Eds.). Pudoc Wageningen, Netherlands, pp: 271-274.

Farrell, D.J., 1979. Energy systems for pigs and poultry: Rev. J. Aust. Inst. Agric. Sci., 34: 21-34.

Fatufe, A.A., I.O. Akanbi, G.A. Saba, O. Olowofeso and O.O. Tewe, 2007. Growth performance and nutrient digestibility of growing pigs fed a mixture of palm kernel meal and cassava peel meal. Livestock Research for Rural Development (LRRD) Vol. 19, Art. No. 180 Retrieved April 8, 2008, from http://www.cipav.org.co/lrrd19/12/fatu19180.htm.

Halimani, T.E., L.R. Ndlovu, K. Dzama, M. Chimonyo and B.G. Miller, 2007. Growth performance of pigs fed on diets containing *Acacia karroo*, *Acacia nilotica* and *Colophospermum mopane* leaf meals. Livestock Research for Rural Development (LRRD) Vol. 19, Art. No. 12 Retrieved December 5, 2008, from http://www.cipav.org.co/lrrd19/12/hali 19187.htm.

Hansen, M.J., A. Chwalibog and A. Tauson, 2007. Influence of different fibre sources in diets for growing pigs on chemical composition of faeces and slurry and ammonia emission from slurry. Anim. Feed Sci. Technol., 134: 326-336.

Jegede, J.O., T.S.B. Tegbe, A.O. Aduku and S.A.S. Olorunju, 1994. The effect of feeding PKM on performance and carcass characteristics of pigs. Nig. J. Anim. Prod., 21: 88-95.

Kennelly, J.J. and F.X. Aherne, 1980. The effect of fibre addition to diets formulated to contain different levels of energy and protein on growth and carcass quality of swine. Can. J. Anim. Sci., 60: 385-393.

Kidders, D.E. and M.J. Manners, 1978. Digestion in the Pig. Scientechnica, Bristol, UK.

King, R.H. and M.R. Taverner, 1975. Prediction of the digestible energy in pig diets from analysis of fibre contents. Anim. Prod., 21: 275-284.

McDonald, P., R.A. Edwards, J.F.D. Greenhaugh and C.A. Morgan, 1995. Animal Nutrition. 5th Edn., Longman Scientific and Technical, UK.

Morel, P.C.H., T.S. Lee and P.J. Moughan, 2006. Effect of feeding level, live weight and genotype on the apparent faecal digestibility of energy and organic matter in the growing pig. Anim. Feed Sci. Technol., 126: 63-74.

Myer, R.O., P.R. Cheeke and W.H. Kennick, 1975. Utilization of alfalfa protein concentrate by swine. J. Anim. Sci., 40: 885-891.

National Research Council, 1998. Nutrient Requirement of Swine. 10th Revised Edn.. National Academy Press, Washington DC, USA.

Noblet, J., 1998. Net energy for growth in pigs: Application to low-protein, amino acid supplemented diets. Institut National de la Recherche Agro. France, http://www.livestocktrail.uiuc.edu/uploads/porknet/papers/noblet%2Epdf

Noblet, J. and J.M. Perez, 1993. Prediction of digestibility of nutrient and energy values of pig diets from chemical analysis. J. Anim. Sci., 71: 3389-3398.

Noblet, J. and J. van Milgen, 2004. Energy value of pig feeds: Effect of pig body weight and energy evaluation system. J. Anim. Sci., 82: E229-E238.

Noblet, J., X.S. Shi and S. Dubois, 1994. Effect of body weight on net energy value of feeds for growing pigs. J. Anim. Sci., 72: 645-657.

Olomu, J.M., 1995. Monogastric Animal Nutrition: Principles and Practice. Jachem Publ. Benin, Nigeria.

Oluponna, J.A., J.A. Abodunwa, O.O. Adejinmi, F.O. Ogunleke, J.B. Fapohunda and Olubodun, 2002. Performance of rabbits fed brewers' dried grain from different sources. Proceedings of 27th Annual Conference Nigerian Society Animal Prodroduction (NSAP), March 17-21, 2002, Fed. Univ. of Technol. Akure, Nigeria, pp: 239-241.

Pollman, D.S., D.M. Danielson and Jr. E.R. Peo, 1979. Value of high-fibre diets for gravid swine. J. Anim. Sci., 48: 1385-1393.

Preston, T.R. and R.A. Leng, 1987. Matching ruminant production systems with available resources in the tropics and sub-tropics. Technical Centre for Agric. And Rural Cooperation. Pernambul Books, Armidale.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics. 2nd Edn., McGraw Hill Book Co. Inc., New York, USA.

Souffrant, W.B., 2001. Effect of dietary fibre on ileal digestibility and endogenous nitrogen losses in pigs. Anim. Feed Sci. Technol., 90: 93-102.

Stanogias, G. and G.R. Pearce, 1985. The digestibility of fibre by pigs. 1. The effect of amount and type of fibre on apparent digestility, nitrogen balance and rate of passage. Br. J. Nutri., 53: 513-530.

Tram, N.D.Q. and T.R. Preston, 2004. Effect of method of processing cassava leaves on intake, digestibility and N retention by Ba Xuyen piglets. Livestock Research for Rural Development: www.cipav.org. co/lrrd 16/10/tram 16080.htm.

Uden, P. and P.J. Van Soest, 1982. Comparative digestion of timothy (*Phleum pretense*) fibre by ruminants, equines and rabbits. Br. J. Nutri., 47: 267-272.

Van Soest, P. J. and D. G. Fox, 1992. Discount for Net Energy and Protein. 5th Revised Edn., In: Proceedings of the Cornell Nutrition Conferene, Ithaca, New York, pp: 40-68.

Wu, J.F. and R.C. Ewan, 1979. Utilization of energy of wheat and barley by growing swine. J. Anim. Sci., 49: 1470-1477.

Yin, Y.L., R.L. Huang, H.Y. Zhang, C.M. Chen, T.J. Li and Y.F. Pan, 1993. Nutritive value of feedstuffs and diets for pigs: 1. Chemical composition, apparent ileal and faecal digestibilities. Anim. Feed Sci. Technol., 44: 1-27.

Yin, Y.L., T.J. Li, Y.M. Zhang, S.Y. Bin, G.Y. Wu, R.L. Huang, Q.Z. Dai, P. Zhang, Z.P. Hou and H. Yang, 2006. Performance and nitrogen metabolism in weaned pigs fed diets containing different sources of starch. In: Digestive Physiology of Pigs, Book of Abstracts, 10th International Symposium, 25-27th May, 2006. Hotel Munkeberg, Vejle, Denmark. Danish Inst. Agric. Sci., pp: 60.