Palm kernel cake supplemented with cassava flour waste as energy source for pigs

ABSTRACT

Thirty six (36) growing crossbred (Large White X Landrace) pigs (16.14±0.67kg) were used to determine the effect of replacing maize by palm kernel cake (PKC) supplemented with two levels of cassava flour waste (CFW) on the chemical composition of the diets, performance, economy of the production, serum metabolites and hematological values of the growing pigs. Two levels of CFW (20%PKC + 10%CFW and 20%PKC + 20%CFW) were included in the diets of growing pigs to replace 40% maize inclusion on a weight to weight basis in the 42-day feeding trial. The chemical composition of the diets revealed the increase of 74.4-77.6% in the crude fibre content over the control diet with a resultant decrease 10.9-11.7% in the energy concentrations in the test diets. The average daily weight gains, feed efficiency and protein utilization were comparable between the treatment groups. The cost of feed / kg live weight of pigs reduced (P<0.05) significantly at the two levels of supplementation resulting in comparable economic gains at the two levels of replacement. The serum and hematological indices were similar between the groups, but groups differed for serum urea N and creatinine values. PKC supplemented with CFW can be efficiently utilized as energy source by growing pigs without depressing performance in an attempt to reduce the cost of feeding.

Key words: Agro-industrial by-product, cost effective feeding, pig performance, tropical pig production

Farelo de palmiste suplementado com farelo residual de mandioca como fonte de energia para suínos

RESUMO

Trinta e seis suínos (Large White x Landrace) com peso vivo de 16,14± 0,67 kg foram utilizados para determinar o efeito da substituição do milho pelo farelo de palmiste (PKC) suplementado com dois níveis de farelo residual de mandioca (CFW) sobre a composição química das dietas, desempenho, economia da produção, metabólicos do soro e valores hematológicos. Dois níveis de CFW (20%PKC + 10%CFW e 20%PKC + 20%CFW) foram incluídos nas dietas animais para substituir peso a peso a inclusão do milho em 40% num experimento de 42 dias. A composição química das dietas evidenciou aumento de 74,4-77,6 % no teor de fibra bruta em relação à dieta controle, com uma diminuição equivalente em 10,9-11,7 % na concentração de energia nas dietas em avaliação. O ganho de peso médio diário, a eficiência da alimentação e a utilização da proteína foram equivalentes entre os tratamentos. O custo da alimentação/quilograma de peso vivo dos suínos reduziu-se (P<0,05) significativamente nas dietas alternativas, tendo por resultado ganhos econômicos comparáveis entre os dois níveis de substituição. Os valores para o soro e os índices hematológicos foram similares entre os tratamentos, mas os tratamentos diferiram quanto nitrogênio sob forma de ureia presente no soro e os valores da creatinina. PKC suplementado com o CFW pode eficientemente ser utilizado como a fonte de energia na produção de suínos sem comprometimento do desempenho e desta forma possibilitando a redução no custo da alimentação.

Palavras-chave: Subproduto agro-industrial, alimentação de baixo custo, desempenho de suínos, suinocultura tropical
INTRODUCTION

Swine production is a growing enterprise in Nigeria, but the major constraint has been the high cost of feeding because of the high cost and inconsistent availability of the conventional energy and protein sources. This could be as high as up to 75-80% in the fattening herd and 60-65% in the breeding herd (Tewe, 1997). This situation is partly the result of competition between man and livestock for some food and feed ingredients, particularly, energy sources, such as maize. It would therefore be economically expedient to explore the use of non-conventional feed resources (NCFR) or agro-industrial by-product (AIBP), which are abundant and cheap (Okai et al., 2005). These are regarded as unused feed resources that are useless for human consumption or nutrition hence, non-competitive (Adesehinwa, 2008).

Palm kernel cake (PKC) has been reported as a high energy and cost effective feed ingredient that can be utilized in ration formulations for livestock feeding (Zahari & Alimon, 2006; Adesehinwa, 2007). It is abundant in the tropical areas of the world and it is an excellent feed ingredient for animal production due to its availability and low cost (Orumnuyi et al., 2006). The proximate analysis has showed that it can be classified as energy feed, with the chemical component, very similar to that of corn gluten or rice bran (Alimon, 2006; Adesehinwa, 2007). Being a by-product from the palm oil industry, it could be comparatively high in oil content (depending on the level of processing) but dry and gritty. Its worthy of note that its earlier use as feed ingredient was mainly by ruminants (Chandrasekariah et al., 2001) because of its fibrous nature (16-18% and above, depending on type of processing method), low palatability and low availability of amino acids and energy, hence considered unsuitable for non-ruminants.

The shell content, which may reach as high as 10%, contributes a great deal to its high crude fibre content (Alimon, 2006). Analysis has shown that more than 60% of PKC is cell wall component, consisting of 58% of mannan, 12% of cellulose and 4% of xylan (Jaafar & Javis, 1992). Pigs are however, known to have large caecum, hence, could be able to digest the fibre in PKC to a considerable extent. The metabolizable energy (ME) of 10-10.5 MJ kg⁻¹ reported for pigs is higher than for poultry (6.5-7.5 MJ kg⁻¹) (Alimon, 2006). Inclusion rate of 20-25% has been successfully used in Malaysia for growing-finishing pigs (Zahari & Alimon, 2006) while 25-35% inclusion rate has been reported for the same class of pigs in Ghana (Rhule, 1996). However, intake may be depressed if inclusion rate is higher than 30%.

The crude fibre content of most samples of PKC, 16-18%, is acceptable to most ruminants, but considered high for non-ruminants. Hence, the reason it was adjudged not to be suitable if included at high levels in poultry or pig diets (Alimon, 2006; Adesehinwa et al., 2008). Improving the nutritive value of PKC for monogastric animals may therefore require supplementation with a more digestible ingredient, such as cassava flour or meal.

Cassava flour waste/root meal is another agro-industrial by-product that could be exploited as animal feed. It is however, noteworthy that Nigeria is the leading world producer of cassava (Orumnuyi et al., 2006) and its availability in Nigeria is non-seasonal. Several researchers had earlier confirmed the suitability of cassava for pig feeding and the potential of cassava meal as a feed substitute for maize, for all classes of pigs (Adesehinwa, 2008; Adesehinwa et al., 1998). However, certain precautions need be taken to guarantee satisfactory performance of animals on cassava meal diets. These was reported to include the removal of cyanide through boiling, drying, grating, soaking, fermenting or a combination of these processes to produce final products containing not more than 100 ppm HCN, and the prevention of microbial activity during sun-drying, particularly in a humid environment (Tewe & Egbunike, 1988). High cyanide levels and the presence of microorganisms have been demonstrated to reduce performance and induce haematological changes of growing pigs fed sun-dried cassava based rations (Tewe, 2006).

Cassava meal is the powdered residue of the chips and roots after processing to extract edible starch. It is generally inferior in quality to chips, pellets and broken roots with lower starch content (Tewe, 2006). Lack of protein and essential fatty acids that characterize the cassava flour can be amply enriched with PKC. A mixture of PKC and CFW at the ratio of 1:1 or 2:1 is being experimented as a replacement for maize, the conventional energy source, in an attempt to meet the need of small-scale farmers who produce their own feedstuff. The aim of this study was therefore, to replace the maize fraction of the diets of growing pigs with PKC supplemented with two levels of CFW.

MATERIAL AND METHOD

The experiment was carried out at the Swine Research Unit of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan.

Sources of Ingredients

The test ingredients (PKC and CFW) and other feed ingredients used in this study were sourced locally, similar to farmers’ sources. The PKC used is a product of the cottage industries in Nigeria that uses hydraulic press method for oil extraction from palm kernel, while the CFW is waste flour from local cassava flour mill.

Experimental Diets and Animal

The utilization of palm kernel cake supplemented with cassava flour waste in the diets of the growing pigs was investigated using thirty six growing crossbred (Large White X Landrace) pigs with average initial live weight of 16.14±0.67kg. They were injected with Ivomec® (Ivermectin) subcutaneously against endo-and ecto-parasites (1ml/50kg live weight) and were randomly allotted to the three dietary treatment groups in a completely randomized design. The diets contained 20% PKC+10% CFW and 20% PKC+20% CFW as a replacement, weight for weight, for the 40% maize contained in the control diet (Table 1).

The diets were neither formulated to be isonitrogenous nor isocaloric but the pigs were fed with equal quantities of the
feed according to their daily requirements (NRC, 1988). There were six replicates of two animals per treatment group. They were allowed *ad libitum* access to water in the concrete-floored pens where they were kept throughout the 42-day duration of the trial and the performance were monitored.

### Chemical Analysis

The test ingredients and feed samples were analyzed for the proximate chemical composition using the recommended procedures of Association of Official Analytical Chemists (A.O.A.C., 1990). The metabolizable energy content of the diets was determined with the prediction equation reported by Adesehinwa (2008) based on proximate composition. The proximate chemical components and metabolizable energies of the diets on dry matter basis are shown on Table 1.

### Cost Estimations

The costs of ingredients at the time of purchase were used to calculate the total cost of feed/100 kg of the diet. This was further used in the calculation of the cost of feed consumed and the cost of feed/kg live weight gained.

### Hematology and Serum Biochemistry

Six of the twelve experimental pigs in each of the three dietary treatment groups were randomly selected for blood collection at the end of the feeding trial. The bleeding was done in the morning before feeding and 10 ml of blood was obtained from the jugular vein into two sample bottles using a sterilized needle and syringe (Adesehinwa, 2007). The blood samples for serum analysis were allowed to clot before centrifuging to obtain the serum. The separated sera were deanted into bijoh bottles and stored at –10°C until analyzed.

### Statistical Analysis

All the data obtained were subjected to statistical analysis using analysis of variance (ANOVA) procedure of SAS (1999). The significant treatment means were compared using the New Duncan Multiple Range test option of the same software.

### Results and Discussion

#### Chemical Composition

The chemical composition of the test ingredients (PKC and CFW) and diets used in this study are showed in Tables 1 and 2 respectively. The proximate analysis of the PKC was similar to that used by Alimon (2006). Cassava flour waste, on the other hand, had a composition that was different from that reported by Tegbe et al. (1995). The slight variations observed in some of the components could be attributed to the different methods of processing and storage. Alimon (2006) had classified PKC as an energy source, because of the similarity of its chemical composition to that of the corn gluten or rice bran and its low protein content (16-18%). The crude protein, fibre and the fat contents of CFW were very low compared to the PKC. However, the lack of protein and essential fatty acids that characterize the cassava flour seem to have been compensated with the PKC when both ingredients were incorporated in the diets. It was also noticed that PKC, being slightly fatty, masked the powdery nature of the CFW.

### Table 1. Proximate chemical compositions and estimated metabolizable energy of palm kernel cake (PKC) and cassava flour waste (CFW)

| Components            | PKC     | CFW     |
|-----------------------|---------|---------|
| Dry Matter (%)        | 92.65   | 93.75   |
| Crude Protein (%)     | 15.15   | 2.10    |
| Crude Fibre (%)       | 20.71   | 1.82    |
| Ether Extract (%)     | 4.69    | 0.36    |
| Ash (%)               | 4.33    | 10.50   |
| Nitrogen Free Extract (%) | 54.35 | 85.22   |

Estimated Metabolizable Energy (kcal kg\(^{-1}\))

- Calculated with equation reported by Adesehinwa (2008)

### Table 2. Gross and calculated compositions of the experimental diets of growing pigs containing palm kernel cake supplemented with two levels of cassava flour waste

#### Table 2. Composições bruta e calculada das dietas experimentais para suínos em crescimento contendo farelo de palmitste suplementado com dois níveis de farelo residual de mandioca

| Ingredients          | Control | PKC+10%CFW | PKC+20%CFW |
|----------------------|---------|------------|------------|
| Maize                | 4.00    | 9.00       | 0.00       |
| Cassava Flour Waste  | 0.00    | 10.00      | 20.00      |
| Palm Kernel Cake     | 0.00    | 2.00       | 20.00      |
| Maize Offal          | 15.00   | 15.00      | 15.00      |
| Wheat Offal          | 25.00   | 25.00      | 25.00      |
| Groundnut Cake       | 14.00   | 14.00      | 14.00      |
| Blood Meal           | 3.00    | 3.00       | 3.00       |
| Bone Meal            | 2.25    | 2.25       | 2.25       |
| Salt                 | 0.50    | 0.50       | 0.50       |
| Premix\*             | 0.25    | 0.25       | 0.25       |

Calculated proximate compositions

- Calculated with equation reported by Morgan et al. (1975)

| Crude Protein (%)    | 4.77    | 8.32      | 8.47       |
| Ether Extract (%)    | 3.63    | 2.68      | 2.33       |
| Estimated Metabolizable Energy (kcal kg\(^{-1}\)) | 2,669.30 | 2,379.70 | 2,356.50 |

* Pfizer Agricare Grower Premix supplied the following per kg diet: Vit A 10,000,000 IU; Vit D, 2,000,000 IU; Vit E 8,000 IU; Vit K 2.000mg; Vit B1 2.000 mg; Vit B2 5.500mg; Vit B6 1.200 mg; Vit B12, 12 mg; Biotin 30 mg; Folic Acid 600 mg; Niacin 10,000 mg; Panthotenic Acid 7,000mg; Choline chloride 500,000 mg; Vit C 10,000mg; Iron 60,000 mg; Mn 80,000 mg; Cu 8,000mg; Zn 50,000 mg; Iodine 2,000 mg; Cobalt 450 mg; Selenium 100 mg; Mg 100,000 mg; Anti Oxidant 6,000 mg; ** Calculated after Morgan et al. (1975)
diets. The resultant effect of replacing the high energy maize with PKC, a fibrous ingredient, an attribute of most AIBP (Adesehinwa, 2008), could explain the comparably lower energy value obtained for the PKC+CFW diets.

**Performance Characteristics**

The summary of the performance characteristics as affected by the different diets is showed in Table 3. The daily weight gains and feed:gain ratio were not significantly (P>0.05) affected at both levels of inclusion of PKC + CFW. This was in agreement with the findings of Adesehinwa (2007) who observed no adverse effect on dry matter intake, weight gain and feed conversion ratio as a result of the addition of PKC to the diets of growing pigs. The results thus suggested that the lysine and amino acid (AA) levels available in the diets could be considered adequate with the comparable gains of the pigs on the PKC diets to the control. A linear relationship exists between weight gain and dietary protein. It should be noted that a decreasing trend in lysine content resulting from reduced availability of AA in diets containing PKC was expected (Rhule, 1996). The comparable gains obtained with the replacement of 50% of the maize content in the control diet with PKC and the two levels of CFW is evidence that both test diets were able to meet the requirements of this class of pigs.

**Table 3. Performance of growing pigs fed diets containing palm kernel cake supplemented with two levels of cassava flour waste**

| Parameters                  | Control | PKC+10%CFW | PKC+20%CFW | SEM     |
|-----------------------------|---------|------------|------------|---------|
| Average Initial live weight (kg) | 16.50   | 16.17      | 15.75      | 0.67    |
| Average Final live weight (kg) | 30.17   | 32.50      | 31.92      | 1.30    |
| Average Daily weight gain (kg) | 0.33    | 0.39       | 0.38       | 0.03    |
| Average Daily Feed Intake (kg) | 1.17    | 1.17       | 1.17       | 0.00    |
| Average Daily Crude Protein Intake (kg) | 0.21    | 0.23       | 0.22       | 0.01    |
| Feed Conversion Ratio (Feed:GAIN) | 3.99    | 3.64       | 3.47       | 0.23    |
| Protein Efficiency Ratio (PER) | 1.48    | 1.68       | 1.57       | 0.10    |

The efficiency of protein and feed utilization was reported to decrease with increased fibre content in diets (Adesehinwa, 2007) resulting from reduced digestibility and leading to low availability of AAs and energy of the diets. This was expected, taking into consideration the increased fibre contents of the PKC diets (Table 2) but the efficiencies of feed and protein utilization observed in this study were not significantly (P>0.05) affected by the dietary treatments. This is in agreement with earlier findings in related works by Rhule (1996) and Adesehinwa (2007), where no adverse effect was recorded in dry matter intake, body weight gains and feed efficiency as a result of the addition of PKC to the diets of the growing crossbred pigs.

The use of cassava in commercial livestock feeding has been limited by some factors, notably, dustiness, low protein content, hyrocyanic acid and economic of its mixture into the commercial livestock feeds (Tewe & Egbunike, 1988). However, its use in this study in combination with PKC, a relatively higher protein and fat feedstuff, may be responsible for the enhanced performance of the pigs. Iyayi & Tewe (1988) had reported adequacy of cassava peel supplemented with protein sources in place of maize for growing pigs.

**Economy of Production**

The inclusion of PKC as a replacement for maize resulted in 25-32% reduction in the feed cost per kg and a significantly (P<0.05) lower cost of feeding per day (Table 4). There were no observable differences arising from the inclusion of the two levels of CFW. The test diets (containing the PKC + CFW) were more cost effective (P<0.05) than the maize-control diet in terms of the cost of feed required for a kilogramme live weight gain. The relatively cheaper diets brought about better feed conversion, evident in the lowered cost of producing a kilogramme live weight gain. This brought out the real production value of the test diets for the growing pigs, which was closely associated with feed utilization. Phillips (1984) had reported that reducing feed cost was not only to obtain cheaper feed, but was also dependent on the production result obtained with this cheaper feed. Therefore he concluded that the efficiency which the feed was utilized was that, was of major importance, as observed in this study.

**Hematology and Serum Biochemistry**

The serum and hematological parameters of the growing pigs is showed in Tables 5 and 6. Hematology and blood biochemistry are routinely used in veterinary medicine to evaluate the health status of animals and poultry. The influence of diets on haematological and serum biochemical variables that determine the production value of the test diets for the growing pigs, which was closely associated with feed utilization. Phillips (1984) had reported that reducing feed cost was not only to obtain cheaper feed, but was also dependent on the production result obtained with this cheaper feed. Therefore he concluded that the efficiency which the feed was utilized was that, was of major importance, as observed in this study.

**Table 4. Economy of production of growing pigs fed diets containing palm kernel cake supplemented with two levels of cassava flour waste**

| Parameters                  | Control | PKC+10%CFW | PKC+20%CFW | SEM     |
|-----------------------------|---------|------------|------------|---------|
| Feed Cost / kg Diet (A)     | 14.07   | 10.52      | 9.47       |         |
| Feed Cost / Day (A)         | 16.53a  | 12.27b     | 11.08b     | 0.51    |
| Feed Cost / kg Live weight (A) | 56.09a  | 39.33b     | 32.65b     | 1.10    |

**Table 5. Metabolites of growing pigs fed diets containing palm kernel cake supplemented with two levels of cassava flour waste**

| Metabolites                          | Control | PKC+10%CFW | PKC+20%CFW | SEM     |
|--------------------------------------|---------|------------|------------|---------|
| Total Protein (g dl⁻¹)                | 6.49    | 6.30       | 6.36       | 0.05    |
| Albumin (g dl⁻¹)                      | 3.10    | 2.99       | 3.10       | 0.02    |
| Globulin (g dl⁻¹)                     | 35      | 3.31       | 3.29       | 0.03    |
| Urea Nitrogen (mg dl⁻¹)               | 33.38b  | 42.15a     | 44.13a     | 2.84    |
| Creatinine (mg dl⁻¹)                  | 1.24b   | 1.36ab     | 1.49a       | 0.05    |
| Cholesterol (mg dl⁻¹)                 | 147.00a | 186.62b    | 193.50b    | 6.06    |
| Glucose (mg dl⁻¹)                     | 75.13   | 84.13      | 90.13      | 2.75    |

a,b: Means along the same row having different superscript differ significantly (P<0.05)

Rev. Bras. Ciênc. Agrár. Recife, v.4, n.4, p.479-484, 2009
has been established. Nutrition, especially, dietary protein intake is known to affect the live weight and haematological parameters of animals (Mafuvadze & Erlwanger, 2007). Gouache et al. (1991) reported lowered albumin content to be specifically influenced by dietary protein shortage.

Dietary protein quality is dependent upon the adequacy and balance of the ten indispensable amino acids (IAA). A deficiency of one or more of the IAA will not only result in poor growth and other productive functions but may also lower disease resistance (Tripathi et al., 2008). Reduction in concentrations of erythrocytic parameters (such as PCV, RBC counts and Hb concentration) and elevation in MCV are indications of macrocytic (regenerative) anaemia emanating from increased destruction and subsequent enhanced erythropoiesis at liver, spleen and kidneys (Tripathi et al., 2008). However, this was not the case in this study as the total protein, albumin, globulin and hematological parameters were not significantly (P>0.05) influenced by the dietary treatments. It suffices to say that the nutrient profile of the diets was adequate to support the performance of the pigs.

Proteins form the basic unit of cells and other substances that are necessary for body building, repairs and maintenance of homeostasis, regulation of vital body functions, energy source and defense against infectious agents (Adesehinwa, 2008). Protein deficiency has been reported to reduce most haematological and serum parameters (Mafuvadze & Erlwanger, 2007). The higher urea and creatinine values obtained with the PKC + CFW diets may be brought about by the inadequacy or unavailability of the dietary protein, poor digestibility or inefficient utilization of the protein (Adesehinwa & Ogunmodede, 2004), but this was not reflected in the overall performance of the pigs.

**Conclusion**

The inclusion of cassava flour waste (CFW) supplemented with palm kernel cake (PKC) to replace the maize fraction, even totally, in the diets of growing crossbred pigs was beneficial. The cost effectiveness of the diets is an indication that this could be used to increase the profit margin of a growing pig enterprise in an area with the abundance of these agro-industrial by-products.

From the findings in this study, it could therefore be inferred that PKC supplemented with CFW up to 50% of the maize fraction in diets of growing crossbred pigs can be efficiently utilized for the total replacement of the maize fraction without depressing the performance of the animals in an attempt to reduce the cost of feeding.

**Acknowledgement**

The author is grateful to the Executive Director, I.A.R. & T. for the funding of this project and to the staff of the Swine Research Unit for handling the animals and assistance in the collection of data.

**Literature Cited**

Adesehinwa, A.O.K. Growth performance and serum metabolites of young pigs fed maize offal as energy source. East African Journal of Life Science, v. 5, n. 2, p. 87-96, 2004.

Adesehinwa, A.O.K. Utilization of palm kernel cake as a replacement for maize in diets of growing pigs: Effects on performance, serum metabolites, nutrient digestibility and cost of feed conversion. Bulgarian Journal of Agricultural Science, v. 13, n. 5, p. 593-600, 2007.

Adesehinwa, A.O.K. Energy and protein requirements of pigs and the utilization of fibrous feedstuffs in Nigeria: A review. African Journal of Biotechnology, v. 7, n. 25, p. 4798-4806, 2008.

Adesehinwa, A.O.K.; Dafwang, I.I.; Ogunmodede, B.K.; Tegbe, T.S.B. A review of utilization of some agro-industrial by-products in pig rations. Nigerian Journal of Agricultural Extension, v. 11, n. 1-2, p. 50-64, 1998.

Adesehinwa, A.O.K., Dairo F.A.S. ; Olagbegi B.S. Response of growing pigs to Cassava peel based diets supplemented with Avizyme® 1300: growth, serum and hematological indices. Bulgarian Journal of Agricultural Science, v.14, n.5, p.491-499, 2008.
Adesehinwa, A.O.K.; Oggunmode B.K. Performance and serum metabolites of growing pigs fed diets containing “Dusa” and cashew nut testa as protein sources. Indian Journal of Animal Science, v. 74, n. 1, p. 3-6, 2004.

Alimon, A.R. The nutritive value of palm kernel cake for animal feed. Palm Oil Development v. 40, n.1, p.12-14, 2006.

Association of Official Analytical Chemists - A.O.A.C. Official methods of analysis. 15th Ed. Arlington: Association of Official Analytical Chemist, 1990. 1899p.

Chandrasekariah, M.; Sampath, K. T.; Thulasi, A.; Anandan, S. In situ proteink degradation of certain feedstuffs in cattle. Indian Journal of Animal Science, v. 71, n.2, p. 261-264, 2001.

Gouache, P.; Lemoullac, B.; Bleiberg-Daniel, F.; Aubert, R.; Flament, C. Changes in rat plasma apolipoproteins and lipoproteins during moderate protein deficiency: Potential use in the assessment of nutritional status. Journal of Nutrition, v.121, n. 5, p. 653-662, 1991.

Iyayi, E.A.; Tewe, O.O. Effect of protein deficiency on utilization of cassava peel by growing pigs. In: Workshop on the potential utilization of cassava as livestock feed in Africa, Ibadan, Nigeria. Proceedings… Ibadan: IITA/ILCA/Univ. of Ibadan, 1988. p.54-57.

Mafuvadze, B.; Erlwanger, K. H. The effect of EDTA, heparin and storage on the erythrocyte osmotic fragility, plasma osmolality and haematocrit of adult ostriches (Struthio camelus). Veterinarski Arhiv, v. 77, n.5, p. 427-434, 2007.

Morgan, D.J.; Cole, D.J.A; Lewis, D. Energy values in pig nutrition. 1. The relationship between digestible energy, metabolizable energy and total digestible nutrient values of a range of feedstuffs. Journal Agricultural Science, v.84, n.1, p.7-17, 1975.

Okai, D.B.; Abora, P.K.B.; Davis, T.; Martin, A. Nutrient composition, availability, current and potential uses of “Dusa”: A cereal by-product obtained from “Koko” (porridge) production. Journal of Science and Technology, v. 25, n. 1, p. 33-42, 2005.

Orumnuiy, M.; Bawa, G.S.; Adeyinka, F.D.; Daudu, O.M.; Adeyinka, I.A. Effects of graded levels of palm-kernel cake on performance of grower rabbits. Pakistan Journal of Nutrition, v. 5, n. 1, p. 71-74, 2006.

Phillips, G.D. Feed utilization: Principles and new developments in physiology. Canadian Journal of Animal Science, v. 64, n.3, p. 543-549, 1984.

Rhule, S.W.A. Growth rate and carcass characteristics of pigs fed on diets containing palm kernel cake. Animal Feed Science and Technology, v. 61, n.1, p. 167-172, 1996.

SAS Institute Inc. SAS / STAT User’s Guide.Version 8 for Windows. Carry, North Carolina, U.S.A: SAS institute Inc; SAS Campus Drive, 1999.

Tegbe, T.S.B.; Iyeghe, G; Otchere, E.O. Non-conventional feedstuffs for swine: NAPRI’s Experience. In: National Pig Production Workshop Training Manual. Moor Plantation, Ibadan, Nigeria. Proceedings… Ibadan: NAERLS, 1995. p. 168-188.

Tewe, O. O. “Sustainability and Development: Paradigms from Nigeria Livestock Industry”. In: Inaugural Lecture delivered on behalf of Faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Nigeria. Idaban: University of Ibadan, 1997. p. 1-37.

Tewe, O.O. Cassava products for animal feeding. In: Integrated Cassava project. p. 1-3. http://www.cassavabiz.org/postharvest/lvstock_1.htm 10 Nov. 2006.

Tewe, O.O.; Egbunike, G.N. Utilization of cassava in non-ruminant livestock feeds. In: Workshop on the potential utilization of cassava as livestock feed in Africa. Ibadan, Nigeria. Proceedings… Ibadan, Nigeria: IITA/ILCA/Univ of Ibadan, 1988. p.28-38.

Tripathi, M. K.; Mondal, D.; Karim, S. A. Growth, haematology, blood constituents and immunological status of lambs fed graded levels of animal feed grade damaged wheat as substitute of maize. Journal of Animal. Physiology and Animal Nutrition, v. 92, n.1, p. 75–85, 2008.

Zahari, M.W.; Alimon, A.R. Use of palm kernel cake and oil palm by-products in compound feed. Palm Oil Development, v. 40, n.1, p.5-9, 2006.