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

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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, metabolitos 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 uréia 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

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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 (Orunmuyi 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 knew 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 (Orunmuyi 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

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

Tabela 1. *Composição química aproximada e estimativa de energia metabolizável do farelo de palmiste (PKC) e do farelo residual de mandioca (CFW)*

Components	PKC	CFW
Dry Matter (%)	92.65	89.75
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 (%)	54.15	85.22
Estimated Metabolizable Energy (kcal kg^{-1})*	2,844	30.15

* Calculated with equation reported by Adesehinwa (2008)

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 showed on Table 1.

Cost Estimations

The costs of ingredients at the time of purchase were used to calculate the total cost of feed/100kg 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 decanted into bijoh bottles and stored at – 10^0 C until analyzed. The serum metabolites (total protein, albumin, globulin, creatinine, urea, cholesterol and glucose) were determined as described by Adesehinwa (2007). The blood samples for the hematological studies were collected in sample bottles with EDTA before being analyzed its hemoglobin, red blood cells (RBC), packed cell volume (PCV) and white blood cells (WBC) contents as described by Mafuvadze & Erlwanger (2007); Tripathi et al. (2008).

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

Tabela 2. *Composições bruta e calculada das dietas experimentais para suínos em crescimento contendo farelo de palmiste suplementado com dois níveis de farelo residual de mandioca*

Ingredients	Control	PKC+10%CFW	PKC+20%CFW
Maize	40.0	10.0	0.0
Cassava Flour Waste	0.0	10.0	20.0
Palm Kernel Cake	0.0	20.0	20.0
Maize Offal	15.0	15.0	15.0
Wheat Offal	25.0	25.0	25.0
Groundnut Cake	14.0	14.0	14.0
Blood Meal	3.0	3.0	3.0
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			
Crude Protein (%)	17.39	18.39	17.79
Crude Fibre(%)	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_3 2,000,000 IU; Vit E 8,000 IU; Vit K 2,000mg;Vit B_1 2,000 mg; Vit B_2 5,500mg; Vit B_6 1,200 mg; Vit B_{12} 12 mg; Biotin 30 mg; Folic Acid 600 mg; Niacin 10,000 mg; Pantothenic Acid 7,000mg; Choline chloride 500,000 mg; Vit C 10,000mg; Iron 60,000 mg; Mn 80,000 mg; Cu 8,00mg; 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)

The crude fibre contents of the diets increased with the inclusion of PKC as a replacement for maize while the maize-based control diet had the least value. However, the increased crude fibre content diluted the energy contents of the test 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

Tabela 3. *Desempenho de suínos alimentados com dietas contendo farelo de palmiste suplementado com dois níveis de farelo residual de mandioca*

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) lowered 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.

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

Tabela 4. *Economia na produção de suínos alimentados com dietas contendo farelo de palmiste suplementado com dois níveis de farelo residual de mandioca*

Parameters	Control	PKC+10%CFW	PKC+20%CFW	SEM
Feed Cost / kg Diet (₦)	14.07	10.52	9.47	-
Feed Cost / Day (₦)	16.53a	12.27b	11.08b	0.51
Feed Cost / kg Live weight (₦)	56.09a	38.33b	32.85b	3.10

a,b: Means along the same row having different superscript differ significantly (P<0.05)
₦ means Nigerian Naira. ₦ 150.00 = $1.00

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

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

Tabela 5. *Metabólitos do soro de suínos alimentados com dietas contendo farelo de palmiste suplementado com dois níveis de farelo residual de mandioca*

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	41.25a	44.13a	1.84
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)

Table 6. Haemoglobin values of growing pigs fed diets containing palm kernel cake supplemented with two levels of cassava flour waste

Tabela 6. *Valores de hemoglobina de suínos alimentados com dietas contendo farelo de palmiste suplementado com dois níveis de farelo residual de mandioca*

Parameters Packed Cell	Control	PKC+10%CFW	PKC+20%CFW	SEM
Volume (PCV) %	38.75	39.00	39.50	0.62
Red Blood Cell (RBC) x10^{6}µl	7.81	7.56	7.23	0.17
Hemoglobin (Hb) g dl^{-1}	11.86	11.96	12.06	0.18
Total White Blood Cells (WBC) x10^{3}µl	21,150	19,025	19,863	734.03

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 results 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) through reduced or impaired synthesis of the blood cells which are largely proteinaceous. The total serum protein, albumin, globulin and glucose concentrations in the serum were not significantly (P>0.05) affected by the two levels of CFW supplementation in the PKC-based diets. With this, the results obtained with these diets showed that the protein levels in the diets were able to support the normal protein reserve in the pigs in all the groups.

However, variations were observed in the urea nitrogen, creatinine and cholesterol values. The cholesterol levels observed with the PKC diets were comparable (P>0.05) and this could be attributed to the increased ether extract content conferred on the diets by the PKC (Rhule, 1996). Urea is the main nitrogenous end product arising from the catabolism of amino acids that are not used for biosynthetic in mammals (Adesehinwa, 2004). Therefore its production reflects alterations in the dietary intake of protein and pattern of utilization. It could be observed that values recorded for test diets were significantly (P<0.05) higher than for the control. Even though these values were consistent with the normal range reported for growing pigs by Adesehinwa (2004), serum urea and creatinine levels in animals are indicative of muscular wastage (Adesehinwa, 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.

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