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# Effects of cassava peel-leaf mixture supplemented with enzyme and organic acid on growth performance, serum indices and haematological parameters of growing pigs

O. S. AKINOLA*, G. A. AJAYI, O. E. OKE, A. T. AMOS, M. SOGUNLE-OLAJIDE & C. P. NJOKU

*(O.S.A., G.A.A., M.S-O. & C.P.N.: Federal University of Agriculture, Department of Animal Production & Health, Abeokuta, Nigeria; A.T.A.: Federal University of Agriculture, Department of Animal Nutrition, Abeokuta, Nigeria; O.E.O.: Federal University of Agriculture, Department of Animal Physiology, Abeokuta, Nigeria)*

**Corresponding author's email: akinolaos@funaab.edu.ng*

**ABSTRACT**

In a bid to utilize agro-industrial by-products and crop residues in animal feeding, a feeding trial, with 24 male pigs weighing 14.71±3.39 kg, was conducted for twelve weeks in a cross-over design, for two periods. Cassava peel and cassava leaf were combined at a ratio of 3:2 to form cassava peel-leaf (CPLF), to replace maize. The diets were either supplemented with an enzyme (Cellulase) at 0.2 kg/ton or an organic acid (Orgacid®) at 3.0 kg/ton. The treatments were of two groups: 0% CPLF (control) diets (no-additive, enzyme or organic acid) and 50% CPLF (50% maize) diets (no-additive, enzyme or organic acid). Four pigs were assigned to each diet. For each period, parameters measured were performance, haematological and serum biochemical indices. The replacement of maize with 50% CPLF did not reduce ($p > 0.05$) the response of growing pigs. Likewise, supplementation of CPLF with cellulose or organic acid did not significantly ($p > 0.05$) improve the response of growing pigs. CPLF replacement of maize at 50% and the subsequent supplementation with enzyme or organic acid had no effect on the haematological and serum indices measured. Replacing 50% maize with CPLF did not negatively affect the growth performance and blood profile of growing pigs.

**Keywords:** Cassava peel-leaf mixture; growing pigs; growth performance; maize; serum biochemistry; haematological parameters

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## Introduction

Energy feedstuffs are the major challenge in compounding rations of monogastric animals in developing economies of the world. Maize being the most utilized energy feedstuff in non-ruminant nutrition in Nigeria is not being liberally included in formulated rations due to its high cost and scarcity throughout the seasons of the year. Maize is largely utilized by man, livestock and industries; and more recently, in the production of biofuel; which further put pressure on the little available quantity (Irekhore *et al*., 2011). These situations of scarcity and high cost have led to the search for alternatives that can replace it, but at lower cost. However, the alternative feedstuffs must be one less consumed by other major users (man and industries); and should be available in commercial quantities, at low cost to animal producers (Adesehinwa *et al*., 1998).

A typical example of such is cassava (*Manihot esculenta* Crantz) peel. Cassava peel is a by-product obtained by mechanically removing the peels of cassava roots in food processing factories, where products such as gari, fufu and elubo (cassava flour) are being produced for humans' consumption. It is an agro-industrial by-product that has no dietary value to man but utilizable in animal feed to reduce the production cost of animal products (Irekhore *et al*., 2015). It has proven to be a potential replacement for maize in the diet of growing pigs (Akinola *et al*., 2013; Irekhore *et al*., 2015) due to its relatively high energy content. Limit to its use as feedstuff in the diet of non-ruminant is due to high fibre, low protein content and the presence of hydrogen cyanide (Balogun & Bawa, 1997). Its low crude protein content of 5.35% (Aderemi & Nworgu, 2007), can however be overcome by combining it with cassava leaf, a crop residue from the cassava plant.

The crude protein content of dried cassava leaves ranges between 16.7 to 39.9% (Ravindran & Ravindran, 1988; Ly & Ngoan, 2007), making it a rich protein source. It has been used in previous studies (Ngiki *et al*., 2014; Amos *et al*., 2019) to increase the protein contents of cassava root meal fed to monogastric animals. Thus, dietary utilization of cassava peels and leaf meal (CPLF) by pigs will play a vital role in the use of crop residue that could have been discarded as waste (Akinfala & Tewe, 2004), emitting greenhouse gases (Aro *et al.,* 2010) thereby contributing to polluting and global warming.

However, efficient utilization of cassava peels and leaves in pig rations needs some form of physical treatment to break down the fibre encapsulating its soluble nutrients, for easy digestion (Kidder & Manner, 1978) by monogastric animals. The positive effects of dietary supplementation with enzymes on nutrient digestibility have been documented (Adesehinwa *et al.,* 2011; Kiarie *et al.,* 2013; Irekhore *et al.,* 2015). Therefore, the use of enzymes might assist in increasing their utilization. Organic acids are other feed additives that have been used as alternatives to antibiotics after it was banned as a growth promoter (Mroz *et al*., 2006; Wang *et al*., 2009; Upadhaya *et al*., 2014).

Organic acids (OA) are weak acids (Upadhaya *et al*., 2014), that reports have shown to positively improve the growth rate and feed efficiency (Eckel *et al*., 1992; Overland *et al*., 2008) of animals when used. Previous reports indicate that feed supplemented with organic acid had beneficial effects on swine performance (Mroz *et al*., 2006; Wang *et al*., 2009). Its use for pig health and animal productivity has also been reviewed (de Lange *et al*., 2010; Upadhaya *et al*., 2014).

Nutrition affects blood composition and consequently, the condition of the blood affects the animal responses (Oke *et al.,* 2007). Therefore, the evaluation of blood is a means of determining the response of animals to a particular diet. This research, therefore, investigates the effect of feeding a cassava peel-leaf meal mixture in place of maize; and how supplementation with enzyme or organic acids affects the growth performance and blood parameters of growing pigs.

## Materials and Methods

The experiment was carried out at the Piggery Unit of the Directorate of University Farms (DUFARMS) Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The farm lies within latitude 7° 10′ N, longitude 3° 2′ E. It is located in the derived savannah zone of South-Western Nigeria. It has a humid climate with mean annual rainfall of about 1037 mm and a temperature of about 34.7°C. The relative humidity ranges from 63% to 96% in the rainy season (late March to October), and from 55% to 82% in the dry season (November to early March), with an annual average humidity of 82%. The seasonal distribution of annual rainfall is approximately 44.96 mm in the late dry season (January – March); 212.4 mm in the early wet season (April – June); 259.3 mm in the late wet season (July – September) and 48.1 mm in the early dry season (October – December) as documented by Meteorological Station of the Federal University of Agriculture, Abeokuta.

*Processing of cassava peels and cassava leaves*

The cassava peels were sourced from some local gari processing factories within Abeokuta whilst the cassava leaves (excluding the petioles), were harvested from a cassava plantation in Odeda Local Government Area of Ogun State, Nigeria. The leaves were plucked, sun-dried for three (3) days, milled and stored in plastic bags. Similarly, cassava peels were sun-dried, milled and stored before use.

*Experimental diets and animals*

Cassava peel meal (CPM) and cassava leaf meal (CLM) were combined in a ratio 3:2. The combination (CPLF) was used to replace maize at 0% and 50% levels of inclusion in the diets. There were six treatment groups: Three groups of 0% CPLF (no additive, enzyme and organic acid) and three groups of 50% CPLF (no additive, enzyme and organic acid). Cellulase enzyme was added at 200 g/ton of feed while organic acid (Orgacid®) was added at 3kg/ton of feed. The composition of the experimental diet is shown in Table 1. A total of 24 cross-bred (Large White x Landrace) male pigs of initial body weight (BW) of 14.71±3.39 kg were used for the study which ran for two periods, each period lasting six weeks.

For the first period, the pigs were randomly assigned to six dietary treatments with four pigs per treatment, each pig being a replicate. After the first period, the pigs were re-assigned to the same dietary treatments, but diet offered to each pig at this second period was not the same as it received at the first period. The pigs were housed in pens equipped with concrete feeding and watering troughs. The pigs were fed, based on the method of determining feed intake of pigs (De Lange, 1995), twice daily (8:00hr and 4:00hr) in two equal meals, with drinking water offered *ad libitum* throughout the experimental duration. Data were collected on initial weight, final weight and daily feed intake; while daily gain, feed conversion ratio, were calculated for both periods of the study

*Blood analysis*

At the end of each period of the study, 10 ml of blood was collected before feeding on the morning from each of the pigs in each treatment through the jugular vein puncture using sterilized needle and syringes for serum biochemistry and haematological analyses. For haematological analysis, 5 ml of the blood was collected into EDTA sample bottles and gently mixed. The haematological analyses were performed using an Auto haematology analyzer (Mind ray, BC-2800 Vet) to determine the following parameters; Packed Cell Volume (PCV), Red Blood Cells (RBC), Haemoglobin (Hb), White Blood Cells (WBC), Mean Cell Haemoglobin (MCH), Mean Cell Haemoglobin Concentration (MCHC), Mean Cell Volume (MCV), Platelet and Mean Platelet Volume (MPV). The remaining 5 ml meant for serum analysis was allowed to clot before centrifuging to obtain the serum. The separated sera were decanted into sterile bijou bottles for laboratory analyses. The serum metabolites (total protein, albumin, globulin and creatinine) were estimated using commercial kits of Span Diagnostics, Surat, India and Serum calcium was estimated according to the protocols of Lothar (1998).

*Chemical Analysis*

Representative samples of test ingredients were analyzed for chemical composition, macro and micro-minerals; and amino acid profile using the NIRS DS2500 Analyzer. While the diets were analyzed for proximate composition using the methods of the Association of Official

Analytical Chemists (AOAC, 2012). The metabolizable energy content of experimental diets were determined using the equation reported by Pauzenga *et al*. (1985) based on their proximate composition as shown in Equation 1;

$$ME = 37 \times \%CP + 81 \times \%EE + 35.5 \times \%NFE \ldots \text{Equation 1}$$

Where ME =metabolizable energy, CP =crude protein, EE = ether extract, NFE = nitrogen free extract.

*Statistical Analysis*

Using crossover design data were obtained and subjected to analysis of variance using the GLM procedure of Minitab 17 analytical computer package (Minitab, 2016).The following model was used

$$Y_{ijkl} = \mu + \mathcal{D}_i + S_j + P_k + A_l + D * S_{ij} + \varepsilon_{ijkl}$$

Where $Y_{ijkl}$ is the observed response, μ the overall mean, $D_i$ the effect CPLF level in diet i, $S_j$ the effect of supplementations, $P_k$ the effect of period k, $A_l$ the effct of animal k, $D*S_{ij}$ interaction of CPLF levels and supplementation and $\varepsilon_{ijkl}$ the residual error .$D_i$, $S_j$ and $P_k$ were fixed effects, while $A_l$ and $e_{ijk}$ were random components. Tukey Krammer means comparison procedure was used to separate treatment means that are statistically significant ($p < 0.05$) using the same statistical package.

## Results and Discussion

The chemical composition of cassava peel, cassava leaf and their blend (CPLF) are as shown in Table 2. The combining of cassava peel and leaf increased the crude protein and ash while reducing the fibre, NDF and ADF level of the CPLF compared to cassava peel. Ether extract of the blend (CPLF) increased with little change in energy level (Table 2). The blend of cassava root peel and leaf at ratio 3:2 to form CPLF yielded a product with higher CP of 17.35% but with a lower crude fibre level of 8.72% as compared to cassava peel alone. Furthermore, CPLF had higher magnesium, calcium, iron, copper and phosphorus level compared to cassava peel alone (Table 2).

TABLE 1
*Ingredient and proximate composition of the experimental diets supplemented with organic acid and enzyme*

| | 0% CPLF | | | 50% CPLF | | |
|---|---|---|---|---|---|---|
| **Ingredients** | **NO** | **OA** | **ENZYME** | **NO** | **OA** | **ENZYME** |
| Maize | 600 | 600 | 600 | 300 | 300 | 300 |
| Fishmeal (72% CP) | 20 | 20 | 20 | 20 | 20 | 20 |
| Soya meal | 180 | 180 | 180 | 170 | 170 | 170 |
| GNC | 90 | 90 | 90 | 60 | 60 | 60 |
| PKO | 0 | 0 | 0 | 40 | 40 | 40 |
| CPLF | 0 | 0 | 0 | 300 | 300 | 300 |
| Wheatoffal | 59 | 59 | 59 | 59 | 59 | 59 |
| Bonemeal | 30 | 30 | 30 | 30 | 30 | 30 |
| Limestone | 10 | 10 | 10 | 10 | 10 | 10 |
| Lysine | 3 | 3 | 3 | 3 | 3 | 3 |
| Methionine | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Premix* | 3 | 3 | 3 | 3 | 3 | 3 |
| Salt (Nacl) | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Organic acid | 0 | 3 | 0 | 0 | 3 | 0 |
| Enzyme | - | - | + | - | - | + |
| **Total** | **1,000** | **1,000** | **1,000** | **1,000** | **1,000** | **1,000** |
| **Analyzed composition** | | | | | | |
| Metabolizable Energy (kcal/kg) | 3,005 | 2,910 | 3,028 | 2,836 | 2,881 | 2,898 |
| Dry matter (%) | 90.0 | 89.2 | 89.8 | 89.3 | 89.8 | 89.7 |
| Crude protein (%) | 19.6 | 18.7 | 18.9 | 19.8 | 19.6 | 19.3 |
| Fat (%) | 3.9 | 3.5 | 3.9 | 7.2 | 5.9 | 5.8 |
| Crude fibre (%) | 5.2 | 4.9 | 5.0 | 8.3 | 8.4 | 7.7 |
| Ash (%) | 6.1 | 7.6 | 5.4 | 11.2 | 8.7 | 8.7 |
| NFE (%) | 55.1 | 54.4 | 56.5 | 45.9 | 47.3 | 48.3 |

*Mineral-vitamin premix: 8,000,000 Iu vitamin A; 2,000,000 Iu vitamin D3; 8,500 Iu vitamin E; 2,000 mg vitamin K3; 1,700mg vitamin B1; 4,000 mg vitamin B2; 16,000 mg Niacin; 5,000mg Panthothenic Acid; 1,500mg vitamin B6; 10mcg Vitamin B12; 20mcg Biotin; 500mg Folic Acid; 100,000mg Choline Chloride; 20,000mg Iron; 4,000mg Copper; 46,000mg Zinc;75,000mg Manganese; 1,000mg Iodine; 500mg Cobalt; 200mg Selenium; 2,500mg Antioxidant. +Enzyme = Cellulase , 0.2 kg/ton,; OA = Organic acid (Orgacids® is a blend of formic acid, lactic acid, citric acid, Di-malic acid, L-tartaric acid and orthophosphoric acid), 3 kg/ton; GNC = groundnut cake, PKO = palm kernel oil, CPLF = cassava peel+cassava leaf, NO = basal/control diet (with no additive); CPLF = cassava peel+cassava leaf; NO = no additive; OA = organic acid ; Enzyme = cellulose

TABLE 2
*Chemical composition of cassava peel, cassava leaf and cassava peel-leaf (CPLF)*

| **Parameter** (g $kg^{-1}$ DM) | **Cassava peel** | **Cassava Leaf** | **CPLF** |
|---|---|---|---|
| DM | 911.0 | 919.8 | 915.7 |
| ASH | 35.8 | 77.4 | 50.2 |
| Ether Extract | 24.9 | 87.8 | 63.0 |
| Crude Fibre | 98.6 | 70.4 | 87.2 |
| Crude Protein | 71.1 | 276.0 | 173.5 |
| NDF | 444.7 | 286.7 | 375.3 |
| ADF | 191.8 | 170.9 | 179.1 |
| ADL | 51.8 | 55.1 | 50.8 |
| Metabolizable Energy (MJ/kg) | 92.3 | 88.1 | 91.9 |
| **Macro and micro minerals (ppm)** | | | |
| Sodium | 2093 | 1838 | 1894 |
| Potassium | 8458 | - | 1960 |
| Magnesium | 338 | 5128 | 2799 |
| Calcium | *- | 9848 | 4543 |
| Manganese | 96 | * | * |
| Ferric | 1322 | 1309 | 1344 |
| Copper | 3 | 5 | 5 |
| Zinc | 31 | 6 | 18 |
| Phosphorus | 2829 | 4041 | 3589 |

DM = Dry matter; NDF, Neutral Detergent fibre; ADF, Acid Detergent fibre; ADL, Acid Detergent lignin; CPLF = cassava peel+cassava leaf ; * Not detected

Table 3 shows the amino acid profile of cassava peel, cassava leaf and their combination (CPLF). The cassava peel and cassava leaf mixture had an improved amino acid profile as cassava leaf had a superior amino acid profile than cassava peel.

Table 4 shows the main effects of CPLF, type of additive and period on the growth performance of the pigs. A higher level of CPLF had no significant ($p > 0.05$) effect on all performance indices measured. Organic acid and Cellulase did not significantly ($p > 0.05$) improve the response of growing pigs with respect to feed intake, weight gain, final weight and FCR. At the 2nd period of the study, pigs had better ($p < 0.05$) performance than in the 1st period, except for FCR that was not different ($p > 0.05$) between the two periods.

TABLE 3
*Amino acid composition (gm/100gm) of Cassava peel, Cassava leaf and Cassava Peel-Leaf (CPLF)*

| | **Cassava peel** | **Cassava Leaf** | **CPLF** |
|---|---|---|---|
| Aspartic acid | 0.68 | 2.60 | 1.70 |
| Serine | 0.18 | 0.96 | 0.57 |
| Glutamin acid | 0.32 | 2.77 | 1.63 |
| Glycine | 0.46 | 1.15 | 0.79 |
| Histidine | 0.18 | 0.55 | 0.37 |
| Arginine | 0.19 | 0.98 | 0.65 |
| Threonine | 0.16 | 1.12 | 0.67 |
| Alanine | 0.37 | 1.27 | 0.81 |
| Proline | 0.32 | 0.90 | 0.58 |
| Cysteine | 0.03 | 0.17 | 0.09 |
| Tyrosine | 0.07 | 0.95 | 0.53 |
| Valine | 0.23 | 1.35 | 0.81 |
| Methionine | 0.03 | 0.35 | 0.18 |
| Lysine | 0.31 | 1.28 | 0.78 |
| Isoleucine | 0.11 | 1.09 | 0.61 |
| Leucine | 0.30 | 1.99 | 1.17 |
| Phenylalanine | 0.18 | 1.49 | 0.87 |
| Tryptophan | - | 0.35 | 0.17 |

CPLF = cassava peel+cassava leaf

TABLE 4

*The main effect of a control diet and CPLF replacing maize diets, supplemented with organic acid and enzyme on the growth performance of growing pigs*

| | CPLF | | | Supplements | | | | Periods | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameters** | **0%** | **50%** | **P** | **NO** | **OA** | **ENZYME** | **P** | **1** | **2** | **P** | **SEM** |
| Initial weight (kg) | 23.33 | 22.54 | 0.601 | 21.56 | 23.918 | 23.34 | 0.412 | 14.77[b] | 31.10[a] | 0.000 | 1.420 |
| Final weight (kg) | 44.85 | 42.01 | 0.162 | 42.31 | 45.75 | 42.16 | 0.260 | 29.31[b] | 57.55[a] | 0.000 | 2.310 |
| Feed intake (kg)/day | 1.39 | 1.37 | 0.7924 | 1.39 | 1.48 | 1.27 | 0.123 | 0.93[b] | 1.84[a] | 0.000 | 0.0789 |
| Weight gain (kg)/day | 0.51 | 0.48 | 0.263 | 0.49 | 0.52 | 0.47 | 0.403 | 0.35[b] | 0.64[a] | 0.000 | 0.027 |
| FCR | 2.73 | 2.90 | 0.378 | 2.82 | 2.87 | 2.75 | 0.890 | 2.68 | 2.96 | 0.0897 | 0.137 |

CPLF = cassava peel + cassava leaf; NO = no additive; OA = organic acid; Enzyme = cellulose

TABLE 5

*Interactive effect of CPLF and supplementation with organic acid or enzyme on the growth performance of growing pigs*

| | Diets | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0% CPLF | | | 50% CPLF | | | | |
| **Parameters** | **NO** | **OA** | **ENZYME** | **NO** | **OA** | **ENZYME** | **P** | **SEM** |
| Initial weight (kg) | 22.50 | 24.56 | 22.93 | 20.62 | 23.52 | 23.75 | 0.747 | 1.420 |
| Final weight (kg) | 44.25 | 47.25 | 43.05 | 40.38 | 44.25 | 41.25 | 0.903 | 2.330 |
| Feed intake (kg)/day | 1.45 | 1.50 | 1.22 | 1.33 | 1.46 | 1.36 | 0.566 | 0.079 |
| Weight gain (kg)/day | 0.52 | 0.54 | 0.48 | 0.47 | 0.50 | 0.42 | 0.962 | 0.027 |
| FCR | 2.83 | 2.81 | 2.56 | 2.82 | 2.93 | 2.96 | 0.680 | 0.127 |

CPLF = cassava peel + cassava leaf; NO = no additive; OA = organic acid; Enzyme = cellulose

Table 5 shows the interactive effects of the levels of CPLF and type of additive on the growth performance of pigs. Pigs fed 0% and 50% CPLF supplemented with organic acids showed marginal improvement ($p > 0.05$) in feed intake, weight gain and final weight over pigs on other diets. Tables 6 and 7 show the main and the interactive effect of the treatments (0%CPLF and 50%CPLF) and additive (NO, OA and enzyme) on serum indices of growing pigs fed the experimental diets. The result revealed that neither the treatments nor the additives had any significant ($p > 0.05$) effect on the serum parameters examined. However, there was an improvement ($p < 0.05$) in Total protein and Albumin in period 2 of the study. The combined effect of CPLF levels and type of additives did not significantly ($p > 0.05$) affect the serum indices measured in this study.

The results of the main and the interactive effect of the treatments (0%CPLF and 50%CPLF) and additive (NO, OA and enzyme) on haematological parameters of growing pigs fed the experimental diets are as presented in Tables 8 and 9. The results reveal that dietary inclusion of enzymes and organic acids did not affect ($p > 0.05$) the haematological indices examined. At period 2, pigs recorded a lower ($p < 0.05$) white blood cell value, while Lymphocytes value increased ($p < 0.05$). The result shows that at 50% CPLF in replacement of maize, in the diet of growing pigs, blood haematological indices measured were not significantly ($p > 0.05$) influential. Furthermore, the use of enzyme and organic acids had no influence ($p > 0.05$) on the haematological indices of pigs. The interactive effect of CPLF level and type of additive did not affect ($p > 0.05$) the haematological indices measured.

TABLE 6

*Main effect of Cassava peal-leaf and supplementation with organic acid or enzyme on serum indices of growing pigs*

| | CPLF | | | Supplements | | | | Periods | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measurement** | **0%** | **50%** | **P** | **NO** | **OA** | **ENZYME** | **P** | **1** | **2** | **P** | **SEM** |
| Total Protein (g/dl) | 6.27 | 5.97 | 0.391 | 6.52 | 6.28 | 5.56 | 0.093 | $5.57^b$ | $6.67^a$ | 0.006 | 0.187 |
| Albumin (g/dl) | 3.95 | 3.84 | 0.659 | 4.11 | 4.10 | 3.47 | 0.078 | $3.21^b$ | $4.58^a$ | 0.000 | 0.156 |
| Globulin (g/dl) | 2.32 | 2.13 | 0.513 | 2.41 | 2.18 | 2.10 | 0.664 | 2.36 | 2.09 | 0.380 | 0.133 |
| AST (U/L) | 40.23 | 42.12 | 0.354 | 41.22 | 41.36 | 40.94 | 0.986 | 41.13 | 41.22 | 0.969 | 0.938 |
| ALT (U/L) | 16.31 | 17.81 | 0.238 | 17.39 | 16.81 | 16.99 | 0.925 | 16.94 | 17.19 | 0.849 | 0.560 |
| ALP (U/L) | 47.47 | 50.18 | 0.265 | 50.01 | 47.51 | 48.95 | 0.677 | 49.75 | 47.90 | 0.470 | 1.140 |
| Urea (mg/dl) | 11.56 | 11.14 | 0.489 | 10.45 | 11.79 | 11.81 | 0.109 | 11.69 | 11.01 | 0.295 | 0.309 |
| Creatinine (mg/dl) | 0.91 | 1.00 | 0.445 | 0.98 | 0.93 | 0.95 | 0.913 | 0.93 | 0.98 | 0.653 | 0.051 |
| Calcium (mg/dl) | 11.00 | 11.08 | 0.784 | 10.96 | 11.27 | 10.90 | 0.478 | 10.99 | 11.09 | 0.722 | 0.152 |

[a,b,c] Least square mean values in rows bearing different superscripts are significantly different ($p < 0.05$); CPLF = cassava peel+cassava leaf, NO = no additive, OA = organic acid; Enzyme = Cellulase; AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, ALP: Alkaline phosphatase

TABLE 7

*Interactive effect of Cassava peal-leaf and supplementation with organic acid or enzyme on serum indices of growing pigs*

| | DIETS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 %CPLF | | | 50%CPLF | | | | |
| **Parameters** | **NO** | **OA** | **ENZYME** | **NO** | **OA** | **ENZYME** | **P** | **SEM** |
| **Serum** | | | | | | | | |
| Total protein (g/dl) | 6.48 | 6.68 | 5.66 | 6.56 | 5.89 | 5.46 | 0.565 | 0.187 |
| Albumin (g/dl) | 4.17 | 4.20 | 3.48 | 4.05 | 4.01 | 3.45 | 0.968 | 0.156 |
| Globulin (g/dl) | 2.31 | 2.48 | 2.18 | 2.51 | 1.88 | 2.01 | 0.513 | 0.133 |
| AST (U/L) | 41.50 | 37.93 | 41.24 | 40.93 | 44.79 | 40.65 | 0.223 | 0.938 |
| ALT (U/L) | 16.81 | 16.53 | 15.60 | 17.96 | 17.10 | 18.39 | 0.767 | 0.560 |
| ALP (U/L) | 48.66 | 45.51 | 48.24 | 51.37 | 49.51 | 49.66 | 0.910 | 1.140 |
| Urea (mg/dl) | 10.75 | 12.07 | 11.85 | 10.15 | 11.50 | 11.77 | 0.928 | 0.309 |
| Creatinine (mg/dl) | 0.97 | 0.96 | 0.81 | 1.00 | 0.90 | 1.10 | 0.456 | 0.051 |
| Calcium (mg/dl) | 10.69 | 11.36 | 10.97 | 11.23 | 11.17 | 10.83 | 0.445 | 0.152 |

CPLF = cassava peel+cassava leaf; NO = no additive; OA = organic acid ; Enzyme = cellulose; AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, ALP: Alkaline phosphatase

TABLE 8

*Main effect of CPLF and supplementation with an enzyme or organic acids on haematological parameters of growing pigs*

| | CPLF | | | Supplements | | | | Periods | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measurement** | **0%** | **50%** | **P** | **NO** | **OA** | **ENZYME** | **P** | **1** | **2** | **P** | **SEM** |
| PCV % | 45.2 | 46.6 | 0.491 | 45.0 | 46.1 | 46.7 | 0.782 | 47.1 | 44.8 | 0.266 | 0.95 |
| WBC ($\times10^9$/L) | 18.6 | 20.4 | 0.379 | 18.1 | 20.3 | 20.2 | 0.609 | 24.0[a] | 15.0[b] | 0.000 | 1.31 |
| RBC ($\times10^{12}$/L) | 7.6 | 7.8 | 0.536 | 7.5 | 7.7 | 7.8 | 0.764 | 7.9 | 7.5 | 0.275 | 0.16 |
| Haemoglobin (g/dl) | 15.0 | 15.6 | 0.418 | 15.0 | 15.4 | 15.6 | 0.694 | 15.8 | 14.9 | 0.206 | 0.32 |
| Neutrophils % | 26.2 | 28.9 | 0.163 | 28.6 | 28.0 | 26.0 | 0.529 | 29.4 | 25.7 | 0.069 | 1.01 |
| Lymphocytes % | 70.4 | 67.3 | 0.146 | 67.8 | 68.9 | 69.8 | 0.746 | 66.5[b] | 71.1[a] | 0.046 | 1.14 |
| Eosinophils % | 1.1 | 1.2 | 0.704 | 1.1 | 1.0 | 1.4 | 0.344 | 1.3 | 1.0 | 0.318 | 0.11 |
| Basophils % | 1.2 | 1.1 | 0.878 | 1.3 | 1.0 | 1.2 | 0.613 | 1.2 | 1.1 | 0.705 | 0.14 |
| Monocytes % | 1.1 | 1.5 | 0.282 | 1.2 | 1.2 | 1.6 | 0.592 | 1.6 | 1.1 | 0.202 | 0.20 |
| MCV (fl) | 60.0 | 60.1 | 0.733 | 60.1 | 60.2 | 59.9 | 0.87 | 60.0 | 60.1 | 0.717 | 0.21 |
| MCH (pg) | 20.0 | 20.1 | 0.321 | 20.0 | 20.1 | 20.1 | 0.802 | 20.1 | 20.0 | 0.662 | 0.08 |
| MCHC (g/dl) | 33.3 | 33.4 | 0.212 | 33.2 | 33.3 | 33.6 | 0.084 | 33.5 | 33.2 | 0.095 | 0.07 |

[a,b,c] Least square mean values in rows bearing different superscripts are significantly different ($p < 0.05$); CPLF = cassava peel+cassava leaf; NO = no additive; OA = organic acid; Enzyme = cellulose; PCV: Packed cell volume, WBC: White Blood Cell, RBC: Red Blood Cell, MCV: Mean Corpuscular Volume; MCH: Mean Corpuscular Haemoglobin, MCHC: Mean Corpuscular Haemoglobin Concentration

TABLE 9

*Interactive effect of CPLF and supplementation with an enzyme or organic acids on haematological parameters of growing pigs*

| | DIETS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 %CPLF | | | 50%CPLF | | | | |
| **Parameters** | **NO** | **OA** | **ENZYME** | **NO** | **OA** | **ENZYME** | **P** | **SEM** |
| **Haematology** | | | | | | | | |
| PCV (%) | 41.59 | 45.31 | 48.86 | 48.45 | 46.88 | 44.45 | 0.079 | 0.948 |
| WBC ($\times 10^9$/L) | 18.79 | 18.79 | 18.29 | 17.45 | 21.76 | 22.09 | 0.539 | 1.310 |
| RBC ($\times 10^{12}$/L) | 6.92 | 7.59 | 8.15 | 8.07 | 7.76 | 7.44 | 0.096 | 0.162 |
| Haemoglobin (g/dl) | 13.76 | 15.05 | 16.32 | 16.14 | 15.65 | 14.94 | 0.080 | 0.319 |
| Neutrophils (%) | 26.55 | 27.98 | 24.10 | 30.69 | 27.98 | 27.98 | 0.589 | 1.010 |
| Lymphocytes (%) | 69.63 | 69.77 | 71.77 | 65.92 | 68.06 | 67.77 | 0.888 | 1.140 |
| Eosinophils (%) | 1.26 | 0.69 | 1.42 | 0.98 | 1.26 | 1.40 | 0.310 | 0.113 |
| Basophils (%) | 1.17 | 0.88 | 1.45 | 1.46 | 1.03 | 0.88 | 0.502 | 0.142 |
| Monocytes (%) | 1.39 | 0.68 | 1.27 | 0.96 | 1.68 | 1.96 | 0.275 | 0.196 |
| MCV (fl) | 60.16 | 59.77 | 59.94 | 60.02 | 60.55 | 59.79 | 0.635 | 0.210 |
| MCH (pg) | 19.93 | 19.87 | 20.06 | 20.00 | 20.23 | 20.17 | 0.777 | 0.082 |
| MCHC (g/dl) | 33.09 | 33.22 | 33.52 | 33.31 | 33.41 | 33.59 | 0.896 | 0.066 |

CPLF = cassava peel+cassava leaf; NO = no additive; OA = organic acid ; Enzyme = cellulose; CPLF: cassava peel-leaf mixture, NO: no additive, OA: Organic acids, PCV: Packed cell volume, WBC: White blood cells, RBC: Red blood cells, MCV: Mean corpuscular volume, MCH: Mean corpuscular haemoglobin, MCHC: Mean corpuscular haemoglobin concentration

This study made an effort at obtaining benefits from the use of readily available and cheap feedstuff with and without additives. Two feedstuffs combined into one to form Cassava peel leaf meal (CPLF) i.e. cassava peel meal and cassava leaf meal at ratio a 3:2 was used at 50% in place of maize in swine diet. Reports from previous studies (Akinola *et al*. 2013; Akinola *et al*. 2016) on cassava peel and cassava leaf informed the level of CPLF adopted in this study. Cassava peel is relatively low in both energy density (19.23MJ/kg) and crude protein (7.1%), while cassava leaf is relatively low in energy density (18.8MJ/kg) but high in crude protein (27.6%). Cassava peel appears to be higher than cassava leaf in fibre level.

The combination of cassava peel and cassava leaf yields a feedstuff with relatively high crude protein; and a more balanced amino acid profile (lysine, 0.78% and methionine, 0.18%) as compared with cassava peel alone which has low crude protein, lysine (0.31%) and methionine (0.03%). The increase in the crude protein of CPLF was due primarily to the ratio of mix of cassava leaf with cassava peel. The combination of cassava leaf meal with cassava peel meal creates a novel feedstuff, CPLF, which has an improved composition and perhaps better quality than the two by-products constituting it. Chemical composition, amino acid profile and the micro and macro mineral composition improved in CPLF with cassava leaf mixed with cassava peel.

The result of this study revealed that supplementing pig's diet with organic acids caused marginal improvement in feed intake and weight gain. Akinola *et al*. 2013, also reported that using cassava peel meal up to 60% replacement of maize with supplemental amino acids resulted in similar feed intake among pigs. While using cassava peel alone in pig feed cause a depression in feed intake (Fatufe *et al*., 2007). Organic acids can therefore be said to cause increased feed palatability leading to higher intake and its subsequent utilization for better weight gain. Brooks *et al*. (2001) shows that lactic acid enhances the palatability of feed. The marginal growth indices reported in this study with the use of organic acids, corroborates the findings of Radecki *et al*. (1988) who report no significant effect on starter pigs fed citric acid supplemented diet.

The inclusion of the cellulase enzyme in CPLF yielded no remarkable improvement in the response of pigs. Some previous studies have shown that exogenous enzymes improved the use of fibre-containing diets by pigs (Nortey *et al*., 2007; Nortey *et al*., 2015; Jang *et al*., 2017), while some reports show no tangible effect of enzyme use (Akinola *et al*., 2016; Masey O'Neill *et al*., 2014).

There was no significant effect of replacing maize with CPLF, supplemented or not with enzyme or organic acids, on serum biochemical and haematological indices of growing pigs. Serum biochemical and haematological measurements fell within the normal ranges for growing pigs (Adesehinwa *et al*., 2008). These imply that the replacement level of CPLF and inclusion of organic acid and enzyme had no negative impact on the health of pigs. Consistent with our findings, Adesehinwa *et al*. (2008) reported that serum indices and haematological parameters of growing pigs fed cassava peel-based diet supplemented with enzyme were unaffected. Similarly, Upadhaya *et al*. (2014) reported that dietary inclusion of organic acids blends did not affect the serum biochemical parameters of finishing pigs. The similar values for haematological parameters reported in this study with the animals fed both basal diet and experimental diets indicate nutritional adequacy of the diets; and the animals were not anaemic. Haemoglobin and red blood cells values falling below the normal range indicates anaemia (Togun *et al.,* 2007 and Bunn, 2011).

White blood cells and their differentials play a vital role in the immune defense system of animals (Ameen *et al.,* 2007) and their deviation from the normal ranges indicates nutritional stress (Etim *et al*., 2014) when higher; but a decrease reflects a fall in the production of defensive mechanisms to combat infection (Eheba *et al*., 2008). The normal WBC and its differentials values reported in this study imply that the experimental diets, whether supplemented or not, did not affect the immune system.

Normal serum protein, albumin and globulin levels are indicators of protein adequacy in terms of quality and quantity in the diet (Akinfala & Tewe, 2001). They are measures of the total amount of protein in the blood (Coles, 1986). The absence of significant variations in the serum indices reported in the current study implies that supplementation did not influence the diet from supporting the protein reserves of the animals, resulting in efficient protein utilization (Adesehinwa, 2007). Rehman & Naqvi (1979) had earlier stated that a positive correlation existed between dietary protein intake and total serum proteins. High concentrations of AST and ALT enzymes in the serum indicates hepatocellular injury or damage (Orororo *et al*., 2014), but this was not the case in this study.

These results showed that the test diets provided the growing pigs with the required nutrients without any toxic effects. Increased serum urea and creatinine levels indicate a decline in kidney function, whereas higher levels of ALT and AST indicate liver damage

(Er & Dik, 2014). In this study, non-significant differences observed in the concentrations of serum urea, creatinine, AST and ALT suggests that supplementing CPLF with organic acids or enzyme had no adverse effects on liver and kidney function. The non-significance value for serum calcium is indicative of its adequacy for good bone mineral density (BMD) of pigs. This indicates that the protein composition of the control and 50% CPLF diets were adequate enough to support high calcium absorption in pigs' intestine (Kerstetter *et al*., 2007).

## Conclusion and Recommendation

The results obtained from this study indicate that the combined use of cassava peel meal and cassava leaf meal was a novel way of utilizing resources that would have otherwise caused environmental pollution by the generation of greenhouse gases inter alia. Cassava peel meal and cassava leaf meal combined at a ratio of 3:2 as a replacement for maize, at 50% can be used in the diets of growing pigs without adverse effect on growth performance and blood indices. The organic acids or enzymes did not improve cassava peel-leaf meal (CPLF) use by pigs. The use of CPLF can be used to prevent the over-dependence on maize and reduce the current rising cost of maize, particularly in developing tropical countries.

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