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The Chemical Composition, Anti-nutritional and Microbial Properties of Ensiled Cassava Root-Leaf Blends as Potential Feed in Swine Diet

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ABSTRACT

A study was conducted to determine the effects of ensiling on the proximate and mineral composition, anti-nutritional factors and microbial properties of ensiled cassava root-leaf blends at 50:50, 60:40, 70:30 and 80:20 ratios in an air tight sealed bottles and to also determine the blend that could replace maize in swine diet. The data was subjected to one-way analysis of variance in a completely randomized design. Results of the study indicated that blend 50:50 had highest value of crude protein 12.96%, while blend 60:40 had highest gross energy value of 4617.17 kcal/kg. Blend 70:30 had gross energy of 4180.95 kcal/kg and crude protein of 10.12%. Results of the mineral composition revealed that blend 50:50 had highest values of calcium 5.96 g/kg and phosphorus 1.98 g/kg. Anti-nutritional factors of the blends were drastically reduced after ensiling. Microbial load of ensiled blends revealed that only blend 70:30 recorded the presence of *Lactobacillus* spp., while *Salmonella* spp. was not detected in all the blends. It was concluded that ensiling was effective for removal of anti-nutritional factor, improving chemical composition and hygienic quality of ensiled product. Blend 70:30 was recommended as a replacement for maize in swine nutrition.

Keywords: Cassava root-leaf blends, ensiled, microbial properties, mineral contents, proximate composition, swine nutrition

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INTRODUCTION

The major source of energy feedstuff in Nigeria is maize where it constitutes about 30-40% of formulated swine diet. In recent times, the cost of maize has increased considerably due to increased production

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of biofuel and droughts in some parts of Africa (United States Department of Agriculture [USDA], 2015). Consequently, the availability or supply does not meet its demand and livestock producers appear most hit in terms of scarcity and high cost of feedstuff (Hamzat et al., 2003). This has accelerated the demand to find alternative feed resources that can replace maize in swine diets and at a lower cost of production. Cassava, a nutritionally rich energy feedstuff which production is sustainable with a metabolizable energy of 3265 kcal/kg (Kanto & Juttupornpong, 2002) offers a veritable cheap alternative. Cassava can completely or partially replace maize of metabolizable energy 3300kcal/kg (Lesson & Summer, 2001) as an energy source for all classes of pigs requiring 2600-3200kcal/kg (National Research Council [NRC], 2012) in their diets (Nnadi et al., 2010).

The majority (70%) of the world's cassava is produced in Nigeria, Brazil, Indonesia, Democratic Republic of Congo and Thailand (Food and Agriculture Organization [FAO], 2015). In 2016, Nigeria produced about 46 million metric tonnes of cassava making the country the world's largest producer (FAO, 2016). Cassava root is composed almost exclusively of carbohydrate, as well as approximately 1-3% crude protein (Stupak et al., 2006). Cassava can be grown in areas with poor fertility as it is resistant to adverse environments and tolerates a range of rainfalls (Montagnac et al., 2009), thus, making its cultivation not seasonal. The crop is cultivated across the country. The high energy content and all year-round availability of cassava compared to maize makes it a potential replacement for maize in swine diet and can be relied upon to provide the anticipated relief against the increasing cost of livestock feeds. However, potential utilization of cassava roots as feedstuff is limited by some factors which include; low crude protein content (1-3%), anti-nutritional factors majorly cyanogenic glycosides and rapid perishability (Eruvbetine et al., 2002).

One of the remedies to these limitations is the supplementation of cassava root with cassava leaf which is richer in crude protein content (21%; Kanto & Juttupornpong, 2002). Cassava leaves, regarded as farm waste during harvesting of cassava roots, have been shown to be rich in protein, minerals (calcium, phosphorus) vitamins (A, B and C) and essential amino acids (leucine and lysine) (Adewusi & Bradbury, 1993). The leaves and tender stems are underutilized as they are often left to rot away on farmsteads in cassava producing areas (Aderemi et al., 2006). Nevertheless, it also contains anti-nutritional factors like the roots (Wobeto et al., 2007) and requires proper processing to reduce or eliminate these anti-nutritional factors.

Sun drying process is probably the cheapest and most common method used in the tropics for effective removal of anti-nutritional factors such as cyanide, oxalate and phytate in cassava (Cardoso et al., 2005; Wanapat, 2009). However, it is season dependent, laborious and time consuming. Ensiling is another method which is as

nearly as good as sun drying for preservation and reduction of anti-nutrients (Phuc et al., 2001). Ensiling process has been found to be an efficient means of reducing cyanide and other anti-nutritional factors to its barest negligible concentration and increasing nutritional value of cassava (Borin et al., 2005; Tetchi et al., 2012). In addition, the process has been reported to improve the nutritional composition of cassava peels (Adeleke et al., 2017), cassava mash (Oduah et al., 2015; Oluwafemi & Udeh, 2016). Furthermore, the process is cheap, simple and not season bound. According to Limon (1992), one of the advantages of cassava silage is that the preservation is guaranteed for several months, thus eliminating another limitation of cassava; rapid perishability.

However, the preservation of silage depends on the production of sufficient acid to inhibit activity of undesirable microorganisms under anaerobic conditions. Lactic acid bacteria (LAB) naturally present on forage crops are responsible for silage fermentation and also influence silage quality (Lin et al., 1992). During silage fermentation, LAB converts sugar into lactic acid and as a result, the pH is reduced and the forage is well preserved (Cai et al., 1999).

Ensiling is therefore postulated to be one of ways of tackling the problems of cassava root utilization in animal nutrition since it tends to proffer solution to most of its limitations, especially when combined with cassava leaf. Thus, this study was aimed at determining the proximate composition, mineral contents, anti-nutritional factors and microbial properties of different ratios of ensiled cassava root-leaf blends and to determine which of the blends will be nutritionally sufficient to replace maize in swine diet.

MATERIALS AND METHODS

The experiment was carried out at the Animal Nutrition Laboratory, College of Animal Science and Livestock Production located within latitude 7° 13' N and longitude 3° 26' E (Google Map, n. d.), Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

Collection and Processing of Cassava Root and Leaf

The cassava roots (TMS 30572) were harvested fresh from the demonstrating farm of the Federal university of Agriculture, Abeokuta, Ogun State. They were rinsed in water to remove the adhering dirt and sand and then grated in a locally fabricated cassava grinding machine (diesel engine of 8hp, Lagos, Nigeria). The ground (sieve size 2mm) unpeeled cassava roots were then packed in Hessian bags and placed under locally fabricated screwed pressed hydraulic presser (cassava dewatering machine) for 24 hours for the purpose of removing effluent as described by Kuye and Sanni (2002). The leaf biomass (consisting of leaves, petioles and stalk) remaining after harvesting of the roots were collected and wilted overnight to reduce 20% of the moisture content of the leaf biomass and later chopped (into 4cm long). The dewatered cassava pulp and wilted cassava leaf biomass were thereafter mixed together at different ratios.

Ensiling of Cassava Root and Leaf

Ensilage procedures were conducted for 21 days according to the methods employed by Hang (1998) in air tight cylindrical glass bottles sealed bottles with a capacity of (1400cm^3) using varying mixtures of grated, dewatered cassava pulp and dried cassava leaves at different ratios of 50:50, 60:40, 70:30 and 80:20 as described by Eruvbetine et al. (2002).The bottles were filled with the premixed materials as quickly as possible and compacted properly to eliminate remnant air so as to minimize the loss of nutrients by oxidation. A polythene sheet was used to cover the ensiled material to create anaerobic conditions for fermentation. Silages were made in quadruplicate to have a total of sixteen samples in all. The bottles were stored at room temperature and placed on the laboratory shelves. At the end of the ensiling procedure with a resultant blend of pH value range 4-5, representative sample of each of the blends were chemically analyzed.

Determination of pH. Ten (10) g of each sample was taken and crushed. Twenty (20) ml of distilled water was then added and the mixture homogenized properly. The pH was measured using a pH meter (INOLAB 730) with glass electrode (Association of Official Analytical Chemists [AOAC], 1995).

Chemical Composition of Ensiled Cassava Root-Leaf Blends

Determination of Proximate Composition. Proximate composition (dry matter, crude protein, crude fibre, ether extract and nitrogen free extract) of dewatered cassava root pulp, wilted cassava leaf biomass and samples of ECRLB were determined using standard analytical methods as described by Association of Analytical Chemists (AOAC) (1995); Dry matter was determined by oven drying at 100^o C for 24 hours, the nitrogen (N) content of the feed was determined by Kjedhal method and the crude protein was estimated as N x 6.25, ether extract was determined by Soxhlet fat analysis as; % Fat = weight of fat/ weight of sample x 100 crude fibre was determined by Weende method and calculated as; % crude fibre = $(W_1 – W_2)/W$ x 100. Where W_1 = weight before ashing, W_2=weight after ashing, W= weight of sample. Total ash was done using the furnace incineration gravimetric method, while the nitrogen free extract was calculated as: 100%- (%CP +% CF+ %EE+ % Ash). The gross energy values of the blends were determined according to standard procedures using the Adiatic Bomb Calorimeter (Model 1261; Parr Instrument Company, Moline, IL, USA).

Mineral Composition. Mineral content (calcium, magnesium, potassium, sodium, iron, copper, manganese, zinc and phosphorus) of the samples were determined according to the standard protocols described by Sodamade et al. (2013) as follows: one (1) g of each of the samples were weighed and subjected to dry ashing in a well cleaned porcelain crucible at 50^{o}C in a muffle furnace. The resultant ash was dissolved in 5.0 ml of HNO_3/HCl/ H_2O (1:2:3) and heated gently on a heating

mantle until brown fumes disappeared. Five (5.0) ml of distilled water was added to each of the sample in the crucible and heated until colourless solution was obtained. The mineral solution was filtered into a 100 ml volumetric flask through filter paper and the volume was made to the mark with distilled water. The solution was analyzed for its elemental composition using parking Elmer 403 model of atomic absorption spectrophotometer.

Anti-nutritional Composition. The anti-nutritional composition of the blends was determined before and after ensiling. Hydrogen cyanide compositions of the blends were determined through the alkaline titration procedure as described by Anhwange et al. (2011). Ten (10) grams of each of the samples were ground and soaked in the mixture of 200 cm^3 of distilled water and 10 cm^3 of orthophosphoric acid. The mixture was kept for 12 hours to release all the bounded cyanide. The mixture was then distilled until 150 cm^3 of the distillate were collected. Twenty (20) cm^3 of the distillate were poured into a conical flask containing 40 cm^3 of distilled water. Eight (8 cm^3) of ammonia solution (6 mol/dm^3) and 2 cm^3 of potassium iodide (5%) solution were added. The mixture was then titrated with silver nitrate (0.02 mol/dm^3) to faint but permanent turbidity, 1cm^3 (0.02 mol/dm^3 $AgNO_3$) is equivalent to (1.08 mg HCN). The percentage hydrocyanide was calculated with the formula:

$$Hydrocyanide\ (\%) = \frac{Titre \times 10 \times 0.27 \times 100}{1000 \times weight\ of\ sample}$$

Determination of Phytic Acid. The phytic acid was determined using the procedure described by Haritha and Jayadev (2017). About 2.0 g of each of the samples were weighed into 250 ml conical flask. One hundred (100) ml of 2% concentrated HCl acid was used to soak each sample in a conical flask for 3 hours and then filtered through a double layer of hardened filter papers. Fifty (50) ml of each filtrate was placed in 250 ml beaker and 100 ml of distilled water was added to each to give proper acidity. Ten (10) ml of 0.3% ammonium thiocyanate solution was added into each solution as indicator. Each solution was titrated with standard iron chloride solution, which contained 0.00195 g iron per ml. the end point colour was brownish-yellow which persisted for 5 minutes. The percentage phytic acid was calculated.

Determination of Tannin. For the determination of tannin, protocols described by Makkar et al. (1993) was adopted. About 400 mg of each of the samples were placed into two conical flasks and 40 ml diethyl ether containing 1% acetic acid (v/v) was added, then the mixtures were properly mixed to remove the pigment materials. Each supernatant was carefully discarded after 5 minutes and 20 ml of 70% aqueous acetone was added and the flasks was sealed with cotton plug covered with aluminum foil and then kept in electrical shaker for 2 hours for extraction. Each content in the flask was filtered through Whatman filter paper and

samples (filtrates) were for analyzed. Fifty (50 ml) of tannin extract from each sample was taken into test tubes and volume of each was made up to 1.0 ml with distilled water, 0.5 ml Folin-Ciocalteu reagent was added to each and mixed properly. Then 2.5 ml of 20% sodium carbonate solution was added and mixed. The mixtures were kept for 40 minutes at room temperature, after which absorbance was taken using spectrophotometer and concentration was estimated from the tannic acid standard curve.

Determination of Oxalate. Oxalate was determined by using the method described by Haritha and Jayadev (2017). One (1) gram of each sample was placed in a 250 ml volumetric flask, 190 ml of distilled water and 10 ml of 6 m HCl was added. Each mixture was warmed on a water bath at 90°C for 4 hours and the digested samples were centrifuged at a speed of 2,000 rpm (10,000 × *g*) for 5 minutes after which the supernatant was then diluted to 250 ml. Three (3) 50 ml aliquots of each supernatant were evaporated to 25 ml, and then the brown precipitate was filtered off and washed. The solutions were titrated with concentrated ammonia solution in drops until Salmon pink colour of methyl orange changed to faint yellow. The solutions were heated on a water bath to 90°C and the oxalate was precipitated with 10 ml of 5% calcium dichloride ($CaCl_2$) solution. The solutions were allowed to stand overnight and then centrifuged. Each precipitate was washed into a beaker with hot 25% tetraoxosulphate (vi) acid (H_2SO4), diluted to 125 ml with distilled water and after warming to 90°C it was titrated against 0.5 ml potassium tetraoxomanganate (vii) ($KMnO_4$).

Microbial Counts. The Microbial composition of the blends was analysed by using plate count method as described by Cai et al. (1998): Ten (10) g of each of the samples were blended with 90 ml of sterilized distilled water, then a further tenfold serial dilutions ranging from 10^{-1} to 10^{-5} were prepared and incubated anaerobically at 30°C for 48h on lactobacilli de Man, Rogosa and Sharpe (MRS) agar (Difco lab.Inc., Detroit, MI, USA) after which the numbers of *Lactobacillus* spp. were measured by the plate count method. Coliform bacteria were cultivated on blue light broth agar incubated at 30°C for 48h. *Pseudomonas* spp. were investigated on a sterile nutrient agar (oxoid) by pour plate method. Incubation of the plates was carried out at 37°C for 24hours. After incubation, the organisms were enumerated and purified by successive streaking on fresh agar plates. Pure cultures of the organisms on slants were stored at 4°C prior to identification. *Salmonella* spp. were sought on Salmonella-Shigella (SS) agar after a pre-enrichment on Rapport-Vassiliates soja (RVS) agar according to standard method. Total bacteria count was investigated on potato dextrose agar by spread plate method. The media used were prepared and incubated according to the labelled manufacturer's instructions. The colonies were enumerated and expressed as colony forming unit (CFU) per gram of fresh matter.

Statistical Analysis

Determined chemical compositions of the blends were subjected to one-way analysis of variance in a completely randomized design using Statistical Analysis System (SAS) (2000). The means of treatments showing significant differences were compared using Tukey's test. Statistical significance was accepted at P≤0.05.

RESULTS

Results of the proximate composition of ensiled cassava root-leaf blends are as shown in Table 1.The crude protein (CP), crude fibre (CF) and ether extracts (EE) values of the blends ranged from (7.21-12.96%), (18-22%) and (10-13.50%) respectively with blend 50:50 recording the highest (P<0.05) values while blend 80:20 recorded the least (P<0.05) values. Gross energy values across the blends ranged from (4180.95- 4671.17 kcal/kg) with blend 60:40 recording the highest value (4671.17 kcal/kg) while 70:30 recorded the least value (4180.95 kcal/kg) as compared to other blends.

The mineral composition of different proportions of ensiled cassava root- leaf blends is presented in Table 2. Highest (P<0.05) concentrations of calcium (Ca), magnesium (Mg), pottassium (K), manganesse (Mn), iron (Fe) and phosphorus (P) were recorded for blend 50:50, while blend 70:30 recorded highest (P<0.05) concentrations of sodium (Na) and copper (Cu) and blend 80:20 recorded highest zinc (Zn) concentration as compared to other blends.

The anti-nutritional factors of cassava root-leaf blends before and after ensiling were as shown in Table 3. There were significant (P<0.05) differences in the ECRLB anti-nutrients (tannin, phytate, HCN and oxalate) determined in this study both before and after ensiling.

The microbial load of ensiled cassava root-leaf blends is presented in Table 4. Total bacterial count and coliform count differed significantly (P<0.05) across the blends. Salmonella species were not detected, while Pseudomonas count and Lactobacillus counts did not differ significantly (P>0.05) across the blends.

Table 1
Proximate composition of ensiled cassava root-leaf blends

Composition	Cassava root- leaf ratio				SEM	P. value	DCRP	WCLB
	50:50	60:40	70:30	80:20				
CP (%)	12.96^{a}	10.54^{b}	10.12^{b}	7.21^{c}	0.533	0.021	1.54	24.46
CF (%)	22.00^{a}	20.00^{b}	19.00^{c}	18.00^{d}	0.382	0.034	20.42	28.65
EE (%)	13.50^{a}	12.00^{b}	11.00^{c}	10.00^{d}	0.333	0.031	0.98	25.00
Ash (%)	3.50^{a}	2.80^{b}	2.80^{b}	2.50^{c}	0.103	0.028	2.38	2.98
NFE (%)	35.54^{d}	48.51^{c}	49.78^{b}	52.29^{a}	1.676	0.016	45.00	38.76
DM (%)	87.50^{c}	94.50^{a}	90.00^{b}	91.50^{b}	1.584	0.018	92.35	81.75
Energy(kcal/kg)	4508.00^{b}	4671.17^{a}	4180.95^{d}	4331.63^{c}	38.54	0.046	4227	3957

Note. $^{a, b, c, d}$: means in the same row with different superscripts are significantly different (P<0.05). CP - crude protein; CF - crude fibre; EE - ether extract; NFE - nitrogen-free extract; SEM - Standard error of means; P. value - Probability value. DCRP - dewatered cassava root pulp, WCLB - wilted cassava leaf biomass

Table 2
Mineral composition of ensiled cassava root-leaf blends

Minerals	Cassava root- leaf ratio				SEM	P. value
	50:50	60:40	70:30	80:20		
Calcium (g/kg)	5.96[a]	5.78[b]	4.24[d]	4.33[c]	1.053	0.035
Phosphorus (g/kg)	1.98[a]	1.56[b]	0.43[d]	0.58[c]	0.167	0.024
Magnesium (g/kg)	3.45[a]	3.24[b]	2.65[c]	2.51[d]	0.097	0.028
Potassium (g/kg)	7.72[a]	7.56[b]	6.10[c]	5.46[d]	2.475	0.016
Sodium (g/kg)	1.92[c]	2.01[b]	2.20[a]	2.11[ab]	0.272	0.013
Manganese (mg/kg)	1.73[a]	1.44[b]	0.85[c]	0.66[d]	0.117	0.022
Iron (mg/kg)	49.65[a]	47.56[b]	22.24[c]	19.15[d]	3.549	0.036
Copper (mg/kg)	4.60[a]	4.20[b]	3.38[c]	3.12[d]	0.069	0.041
Zinc (mg/kg)	17.75[a]	16.50[b]	12.01[c]	10.57[d]	0.740	0.044

Note. [a, b, c, d]: means in the same row with different superscripts are significantly different (P<0.05). SEM - Standard error of means; P. value - Probability value

Table 3
Anti-nutritional factors of cassava root-leaf blends before and after ensiling

Parameters	Cassava root-leaf ratio				SEM	P. value
	50:50	60:40	70:30	80:20		
Before ensiling						
Tannin (%)	0.026[a]	0.017[b]	0.010[c]	0.006[d]	0.002	0.010
Phytate (%)	0.031[d]	0.108[a]	0.036[c]	0.048[b]	0.009	0.013
Oxalate (%)	0.029[a]	0.019[b]	0.017[c]	0.013[d]	0.002	0.021
HCN (mg/kg)	0.510[a]	0.475[a]	0.427[b]	0.330[c]	0.021	0.011
After Ensiling						
Tannin (%)	0.012[b]	0.018[a]	0.005[c]	0.003[c]	0.002	0.012
Phytate (%)	0.014[c]	0.052[a]	0.018[c]	0.023[b]	0.006	0.032
Oxalate (%)	0.013[a]	0.011[b]	0.007[c]	0.006[c]	0.004	0.031
HCN (mg/kg)	0.022[a]	0.017[b]	0.014[c]	0.017[b]	0.004	0.010

Note. [a, b, c, d]: means in the same row with different superscripts are significantly different (P<0.05). HCN - Hydrocyanide; SEM - Standard error of means; P. value - Probability value

Table 4
Microbial load of ensiled cassava root- leaf blends after ensiling

Microbial counts (x10^{3}CFU/g)	Cassava root-leaf ratio				SEM	P. value
	50:50	60:40	70:30	80:20		
Total bacteria count	1.210[b]	0.811[c]	0.810[c]	1.610[a]	0.100	0.000
Coliform	0.200[b]	0.300[a]	0.167[b]	0.200[b]	0.017	0.004
Pseudomonas	0.210	0.100	0.137	0.210	0.022	0.224
Lactobacillus	0.000	0.000	0.033	0.000	0.008	0.441
Salmonella	ND	ND	ND	ND	--	--

Note. [a, b, c, d]: means in the same row with different superscripts are significantly different (P<0.05). ND - Not detected; SEM - Standard error of means; P. value - Probability value

DISCUSSION

The feed ingredient that will replace maize successfully in swine diet must have chemical composition similar to those of maize. Proximate composition of the blends reveals that blend 70:30 recorded a crude protein (CP) value of 10.12% which is close to the CP of maize 8.9- 10.0 % as reported by (Osei et al., 1999; Sproule et al., 1988). This implies that it could be used to replace maize in swine diet. The crude protein values for blends 50:50, 60:40 and 80:20 (12.96, 10.54 and 7.21%) reported in this study were higher than values of (12.14, 9.48 and 7.0%) reported by Eruvbetine et al. (2002) for similar proportion of cassava roots and leaf mixture. The difference might be attributed to the processing methods employed, cassava variation and the environmental conditions. Motarjemi (2002), had earlier reported higher nitrogen content incorporated into ensiled cassava roots was found to improve protein quality as well as enhancing nutrient bio availability. The nutritional requirement of pigs (NRC, 2012) reveals that pigs require moderate quantities of protein for growth and development thus making the blends good sources of protein for all classes of swine. As the level of cassava leaves inclusion in the blends increased, there was a corresponding increase in the CP, CF and EE values thus confirming the fact that cassava leaves are good sources of protein, fibre and fat (Akinfala et al., 2002). The crude fibre range (18-22%) obtained in this study was higher as compared to the ones reported in previous literatures Anja et al. (2016; 10.7%) and Ngiki et al. (2014; 12.6%) in cassava root and leaf meal mixture. This higher crude fibre contents may be attributed to the peels, leaves and petioles (leaf biomass) contained in the blends and could be suitable for sows as higher dietary fibre has been reported to be beneficial to sows as it affects sows' colostrum composition (Loisel et al., 2013). However, some form of physical treatment may be needed for efficient utilization by other classes of pigs (Sauer et al., 1991) if ECRLB is to replace maize in their diet. An average crude fibre of 1.93% has been reported for maize by previous researchers (Osei et al., 1999; Sproule et al., 1988). Crude fibre helps in the maintenance of normal peristaltic movement of the intestinal tract and stimulate gut health, hence; diets containing lower fibre could cause constipation and eventually lead to colon disease (Okon, 1983). The ash contents (2.50-3.50%) reported in this study were higher than the recommended ash range of (1.5-2.5%) for nuts, seeds and roots in order to be suitable for animal feeds (Pomeranz & Clifton, 1981). The improved ash contents of the blends were due to the outer peels and leaf biomass contained in the blends, indicating higher mineral profile of the blends as compared to the value of 1.6% reported for maize (Zhai, 2002) and thus, better sources of mineral element in the swine diet. As the level of cassava inclusion in the blends increased, there was a corresponding increase in the level of Nitrogen free extract (NFE) values. Cassava roots have been reported to have higher level of starch and soluble sugars when compared

to maize (Eruvbetine & Adejobi, 2000) and this could be responsible for the higher gross energy values recorded. The gross energy values of the blends were higher than the values reported by Oso et al. (2014; 3919 kcal/kg) and Akapo et al. (2014; 3374.68 kcal/kg) for unpeeled cassava root meal used for feeding broiler chickens and values of (4058 kcal/kg) and (3832 kcal/kg) for cassava root silages registered by (Arajuo et al., 2016; Silva et al., 2008) respectively. In comparison, the gross energy values reported in this study were higher than the average value of maize (4003 kcal/kg) reported in literatures (Osei et al., 1999; Sproule et al*.,* 1988; Zhai, 2002). This further confirms that the blends are potential sources of energy in animal diet and that blend 70:30 which has a gross energy close to maize could conveniently replace maize in swine diet.

The role of minerals in swine metabolism is well documented (Close, 1999). Among other functions, they are important for carbohydrate, fat and protein metabolism and are involved in nutrient transfer across cell membranes (Close, 1999). Cassava leaves have been reported to be rich sources of minerals and vitamins (Buitrago et al., 2002), which could be responsible for the higher concentration of minerals in blend 50:50 that had higher ratio of leaves. Magnesium has been reported to be involved in maintaining electrical potential in leaves and activation of some enzyme systems (Ferrao et al., 1987). Also, calcium in conjunction with phosphorus, magnesium and Manganese is responsible for bone formation. The mineral profile of the blends reported in this study are higher than those reported by Akapo et al. (2014) and Omosuli (2014) for unpeeled cassava roots and boiled cassava roots respectively. The reason for improved mineral content reported in this study could be attributed to the processing differences as fermentation has been said (Motarjemi, 2002) to enhance micronutrient availability. The mineral profile reported in this study proofs sufficient for daily physiological needs of various classes of pigs as established by (Kinh, 2002).

It is an established fact that cassava contains anti-nutritional compounds that affect digestibility and absorption of nutrients (Graf et al., 1987), thus, determination of anti-nutrients is of great necessity. The synergistic efforts of ensiling employed in this study are believed to be responsible for the reduced ANFs values observed after the ensiling procedure. The reduction level of tannin concentration across the blends; 50:50 (54%), 60:40 (53%), 70:30 (50%) and 80:20 (50%) is similar to the reports of (Nakagawa et al., 2002) that stated that about 40-50% of tannin is lost after processing. Anti-nutritional characteristics of tannin include: antioxidant, inhibiting starch and protein digestibility and also hinder iron and thiamin absorption (Bravo, 1998; Silva & Silva, 1999). Phytate is another anti-nutritional compound found in abundance in cassava roots (Marfo et al., 1990). The phytate range (0.14-0.052g/100g**)** reported after processing in this study was lower than the values reported by Oboh (2006; 7.05mg/g) during the fermentation of cassava peels

and Omosuli (2014; 0.79mg/100g) in boiled cassava roots. Phytate reduction has been attributed to the activity of the endogenous phytate enzyme from the raw ingredient and inherent microorganisms which are capable of hydrolyzing the phytic acid in the fermented food preparations into inositol and orthophosphate (Sandberg & Andlid, 2002). Phytates have been known to form insoluble salts with metals thus, making them unavailable for absorption in the body (Igbabul et al., 2014), so reduced level of phytates in feeds improves the availability and absorption of required metal ions in the body. Oxalates are anti-nutrients that negatively affect Ca and Mg bioavailability, form complexes with protein and inhibit peptic digestion (Massey, 2007; Oboh, 1986). Oxalate contents (0.006-0.013g/100g) reported in this study falls within the recommended level of (<0.05%) ingestion by non-ruminants (Rahman et al., 2012). The greater percentage reduction of HCN concentration across the blends (50:50; 95.7%), (60:40; 96.42%), (70:30; 96.72%) and (80:20; 94.85%) after processing establishes the fact that fermentation is a very effective process for eradication of endogenous cyanic compounds in cassava roots as reported by previous researchers (Essers et al., 1996; Igbabul et al., 2014; Kirmayo et al., 2000; Tetchi et al., 2012). A 50% decrease in HCN during the addition of cellulolytic bacteria to improve the quality of cassava flour was reported by Meryandini et al. (2011), while (70-75%) and 85% decrease was observed by Achinewu et al. (1998) and Kobawila et al. (2005) after 72 hours fermentation respectively. The HCN level reported in this study is safe for inclusion by pigs since it is below the lethal dose of 1-3 mg HCN/kg diet reported by Constable et al. (2017) for monogastric animals.

Indigenous natural fermentation has been reported to involve mixed colony of microorganisms (Kobawila et al., 2005). The growth and succession pattern of these organisms were reported to be dependent on factors such as water activity, pH, and substrate (Blandino et al., 2003), thus the microbial as well as resulting physiochemical interactions eventually regulate the number and types of microorganisms that survives to the end of the fermentation process (Brauman et al., 1996; Padonu et al., 2009). The lowest coliform count observed with blend 70:30 may be attributed to the presence of Lactobacillus species in this particular blend which were not present in other blends. Species of lactic acid bacteria have been shown to inhibit coliforms or Enterobacteriacea (Lo et al., 2010). Presence of coliforms in foods may indicate contamination/inadequate conditions of hygiene but which does not confer a significant risk to human health (Alves & Setter, 2000) and consequently animal health. The main source of contamination includes humans, sewage, utensils, processing equipment and environment, handling and storage conditions and rodents (Eze et al., 2008). Presence of coliform counts in the silages produced in this study agrees with the findings of (Napasirth et al., 2015) in silage of cassava residues (cassava

leaves, peel and pulp). Lactobacillus species were only found in blend 70:30 and was present in abundance (3.3 x 10^5CFU/g). No particular reason could be attributed to this. When lactic acid bacteria especially lactobacilli reach at least 10^5 CFU/g of fresh matter, silage can be well preserved (Napasirth et al., 2015). Epiphytic lactic acid bacteria are naturally present in forage crops and are responsible for silage fermentation and also influence silage quality (Lin et al., 1992) by reducing the pH and inhibiting the growth of other harmful bacteria as a result, forage is preserved (Cai et al., 1999). The absence of *Lactobacillus* spp. in other blends could be due to the presence of other fermenting bacteria which are embedded in the total bacteria counts but are not revealed in this study as it is observed that these blends (60:50, 60:40, and 80:20) had a higher concentration of TBC than blend 70:30. The salmonella count recorded zero count for all the blends. Salmonella are pathogenic organisms, the fact that these organisms were not found in the blends is highly positive and confirms the safety of the silage because its presence can pose a risk to animal health in the form of infections, intoxication and feed poisoning (Cai et al., 1999).

CONCLUSION

The study concluded that ensiling improved nutritional qualities of the blends with respect to chemical composition, hygienic quality as well as anti-nutrient reduction and the blends were well preserved. Ensiled cassava root-leaf mixture of 70:30 had chemical composition (energy and crude protein) similar to the widely standardized and reported composition of maize in literatures and could therefore be suggested to replace maize in swine diets. Further study is recommended on the evaluation of this blend in swine diet.

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