Comparative Evaluation of Processed Pork Cuts from Finisher's Pigs Fed Rice Offal's and Millet Hulls Base Diets.

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Abstract
The experiment was conducted to evaluate processed (smoked) pork products of finisher pigs fed rice offal and millet hulls-based diets. A total of eighteen grower pigs were randomly allotted to three dietary treatments designated as T1, T2 and T3.T1 served as control and was fed with maize offal-based diet as a sole fiber source. T2 and T3 served as treatment groups to which maize offal was replaced with 100% millet hulls inclusion level and 100% rice offal inclusion levels respectively. The experiment lasted for 56 days. Thereafter, three finisher pigs were slaughtered and processed and the following parameters were evaluated, crude protein, ash, ether extract, moisture, dry matter, pH, potassium, Calcium, iron and phosphorus as well as sensory characteristics-aroma, flavor, texture and appearance from the specific pork cuts. At the end of the experiment, it was observed that replacing maize offal with rice offal and millet hulls had no adverse effects on the meat quality in terms of proximate composition. values gotten from the smoke hind limbs showed no significant difference for crude protein and ether extract. T3 yielded the most potassium and phosphorus values with 213.56 and 223.43 respectively for smoked bacon. There was no significant difference between the values of crude protein and ether extract.T1 yielded the highest value for phosphorus content with 215.78.T3 smoked pork shoulders yielded the highest crude protein values with 24.65.T1 had a superior value of 5.11 compared to T2 and T3.T3 had the most phosphorus content with 219.56 the results shows that the use of properly processed millet hulls and rice offal up to 100% level as a replacement to maize offal is an effective way to finish pigs used for production of processed(smoked)pork cuts.

Introduction

Pig production is increasing in Nigeria, thus reducing the animal protein supply gap. This could be due to the known fact that pigs are highly prolific with fast growth rate, early maturity, high meat yield (compared to cattle, sheep and goat) and less socio-cultural bias against pigs in these zones. It has also been identified (Amaefule, 2005) that one of the constraints towards the development of pig production in Nigeria is the near absence and very high cost of commercial pig feeds resulting from high cost of conventional feedstuffs like maize, soybean meal and fish meal. Pig development in Nigeria should therefore be based on locally available non-conventional (agro-industrial by-products) feed resources (Amaefule *et al*., 2009) that are not consumed by human beings.

Meat products are rich in nutrient and play important role in human growth and development (Adetunji and Rauf, 2012). In Nigeria, the demand for pork meat is on the increase because they are the most available and affordable especially in southern Nigeria. The high population growth in Nigeria has also led to the increasing demand for the meat products especially poultry (Heise *et* *al*., 2015). Even though pork and beef meat are common in Nigeria, the consumption of these still remain sources of illness if the meat is not properly prepared. This is because meat and meat products can easily be contaminated by bacterial communities.

Meat is a vital protein source known to be one of the cheapest sources of protein and other essential nutrients required in human diets (Onyango *et al*., 2017). In Africa, meat and meat products from domestic animals are major sources of protein to the population and are widely consumed. In Nigeria, meat has an edge over other sources of protein because it is relatively more abundant in all part of Nigeria especially in the Northern part of Nigeria (Eyo, 2006) and constitutes about 70% of the protein intake (Olatunde, 1998).

Pigs require energy and protein (amino acids) for maintenance of normal physiological body functions, growth and reproduction; and for full realization of the high genetic potentials of pigs for increased meat production. Millet hulls and rice offal are fibrous by-products often used as a filling material (in pillows, for example) but rarely as a livestock feed. However, they have been tested in monogastrics (pigs precisely) to have positive effects on the carcass quality (Tran, 2015). These by-products (millet hulls and rice offal) being cheap and readily available will be used to curb the problems of competition and scarcity of conventional feed ingredients. There is serious competition between feed industry and other sources of food which has been resulting in high cost and scarcity of conventional feed ingredients (Onyimonyi and Ugwu, 2007) like maize, soya-bean meal, groundnut cake, fishmeal etc which would have been great effects on the meat quality of pigs. Most importantly, it is widely accepted that processing improves and makes use of less desirable portion of meat and also improve the shelf life of pork, hence this study is undertaken.

Materials and methods

Location of the study

The experiment was carried out at the Swine unit of Teaching and Research Farm of the Department of Animal Production and Health, Federal University Wukari, Taraba State. Wukari is located at longitude 9°47’0” E and latitude 7°51’ 0” N longitude 9°47’ 0”E. The vegetation of the area is predominantly characteristics of savannah zone and with major climatic seasons of wet or rainy seasons, which starts in March or April, and ends in October and the dry season which starts in November and ends in March or April (Taraba state Dairy, 2008).

Experimental Diets

Three dietary treatments were compounded using rice offal and millet hulls. Diet 1 served as control containing 100% maize offal while diets 2 contained 100% millet hulls and diet 3 contained 100% rice offal inclusion levels respectively. The diets were supplemented with 0.2kg /100kg of Quadraxyme® (Table 1).

Experimental Design and Animal Management

Eighteen (18) mixed local breeds of grower pigs with an average weight of 26.83kg were sourced within Wukari metropolis. The pigs were divided into three treatment groups of six animals per group replicated three times in a completely randomized design. Each pen was provided with feeders, drinkers and wallow. Animals were dewormed before the commencement of the experiment. The animals were fed *ad libitum* and the experiment lasted for 56 days with the final weight of 80.07kg.

Table 1: ingredient composition of experimental diets

	Dietary treatments		
Ingredients	T1	T2	T3
Maize	48.00	48.00	48.00
Soya bean meal	25.00	25.00	25.00
Maize offal	25.00	0.00	0.00
Rice offal	0.00	0.00	25.00
Millet hulls	0.00	25.00	0.00
Bone meal	1.00	1.00	1.00
Methionine	0.30	0.30	0.30
Lysine	0.20	0.20	0.20
*Premix	0.20	0.20	0.20
Salt	0.30	0.30	0.30
**Enzyme	0.00	0.20	0.20

*premix composition (per kg of diet): vitamin A, 12500 IU; vitamin D_3, 2500 IU; vitamin E, 50.00 mg; vitamin K_3, 2.50 mg; vitamin B_1, 3.00 mg; vitamin B2, 6.00 mg; vitamin B_6, 6.00 mg; niacin, 40 mg; calcium pantothenic, 10 mg; biotin, 0.08 mg; vitamin B^{12}, 0.25 mg; folic acid, 1.00 mg; chlorine chloride, 300 mg; manganese, 100 mg; iron, 50 mg; zinc, 45 mg; copper, 2.00 mg; iodine, 1.55 mg; cobalt, 0.25 mg; selenium, 0.10 mg; and antioxidant, 200 mg

** Enzyme composition per kg diet: amylase 110,000units, cellulose 500,000.00units, xylanase 1,000,000units, lipase 10,000units, pactinase 30,000.0units and 4,000 units.

Slaughtering

Three finisher pigs (selected from T1, T2 and T3) which weighed averagely 80.07kg were stunned and slaughtered using knife.

Scalding

Scalding was done using hot water and blade.

Evisceration

Evisceration was carried out using knife.

Dissection and collection of pork cuts

After evisceration, pork cuts were collected from the following parts; the hind leg (ham), the belly (bacon) and the shoulder (sausage) from the three treatments and weighed separately. T1 weighed 2kg, T2 weighed 2kg and T3 weighed 2kg.

Processing of pork cuts

The pork cuts were brined using salt according to weight at 125g, 250g and 125g for T1, T2 and T3 respectively. They were allowed to brine for 72 hours in a freezer. On the fourth day, they were removed from the freezer and allowed to defreeze and air dry. Pepper and salt were added and then grilled for about 4 hours. The chops were placed on the grill and the temperature was monitored with a thermometer and the heat was maintained at 100-130 ^{0}c and the grilling process lasted for 30- 50 minutes. The cuts were grilled on both sides till it attained a brown coloration and had cooked perfectly on both sides. The cuts were taken off the grill and let to rest for 1 hour, after which they wrapped with plastic wrap and stored together in cooler for 12 to 24 hours at 0 to 4°C before transporting the different cuts to the laboratory for analysis.

Proximate analysis
Moisture content was determined by using the air oven drying method by AOAC Official Method 990.19 (AOAC 2016). The crude protein (N x 6.25) of the sample was evaluated by micro-Kjeldahl method (AOAC, 2006). Total lipid was determined by the Soxhlet extraction method using petroleum ether (AOAC, 2006). Ash content was determined by method outlined in AOAC (2006). The carbohydrate content was calculated using Muller and Tobin (1980).

Statistical analysis
Data collected were subjected to Analysis of Variance using JMP SAS (2014) version13. Significant level of difference among treatment means were separated using the same statistical tool.

Results and discussion
PROXIMATE COMPOSITION OF SMOKED HINDLIMB
The proximate composition of the smoked hindlimb in table 2 results revealed that there was no significant ($p>0.05$) difference among treatment groups in crude protein of pigs fed on diets T_1 T_2 and T_3 (23.76, 24.65 and 25.78). Ash of pigs fed on diets $T_{1,}$ T_2 and T_3 (1.34, 1.56 and 1.32) is significantly different ($p>0.05$) and was higher compared with pigs fed on diets T_3 with values of 1.32 respectively. Moisture of pig fed on diets T_3 (12.46) is not significantly different ($p>0.05$) and was compared with pigs fed on diets T_2 with values of 12.44 respectively, although there was significant different with treatment T_1 (17.24). Ether extract of pigs at treatment T_1 (5.13), T2 (3.94) and T3 (4.96) were not significantly at ($p>0.05$). Dry matter was also significantly ($p<0.05$) in pigs fed T_1 but similar to T_2 and T_3.

Table 2 Proximate composition of smoked hindlimb

Parameter	T1 Control	T2 Millet hulls	T3 Rice offal	SEM	P-value
Crude protein	23.76	24.65	25.78	0.58	0.12
Ash	1.34	1.56	1.32	0.10	0.30
Moisture	17.24^a	12.44^b	12.46^b	0.30	0.00
Ether Extract	5.13	3.94	4.96	0.40	0.15
Dry Matter	82.76^b	87.56^a	87.54^a	0.61	0.00

Mean bearing different superscript on the same row differ significantly at ($p< 0.05$)

PH AND MINERAL COMPOSITION OF SMOKED HINDLIMB
PH and mineral composition of HAM in table 3 results revealed that there was significant ($p>0.05$) difference among treatment groups in pH of pigs fed on diets T_2 and T_3 (5.44 and 5.12) but there was no significant difference between treatment 1 and treatment 2. Potassium of pigs fed on diets T_2 and T_3 (212.50 and 213.56) were no significantly different ($p>0.05$) but significantly different with treatment 1 with a value 200.32 respectively. Calcium of pig fed on diets T_1, T_2 and T_3 (12.46) is not significantly different ($p>0.05$) with values of 12.67, 11.34 and 11.45 respectively. Iron of

pigs at treatment T_1 (0.80), T2 (0.90) and T3 (0.76) were not significantly at (p>0.05). Phosphorus was also no significantly different (p<0.05) in pigs fed T_1 and T_3 but different to T_2.

Table 3 pH and Mineral composition of smoked hindlimb

Parameter	T1 Control	T2 Millet hulls	T3 Rice offal	SEM	P-value
pH	5.34^{ab}	5.44^{a}	5.12^{b}	0.08	0.07
Potassium	200.32^{b}	212.50^{a}	213.56^{a}	0.63	0.00
Calcium	12.67	11.34	11.45	0.55	0.24
Iron	0.80	0.90	0.76	0.04	0.15
Phosphorus	214.76^{b}	234.87^{a}	223.43^{b}	2.80	0.00

Mean bearing different superscript on the same row differ significantly at (p< 0.05)

PROXIMATE COMPOSITION OF BACON

The proximate composition of BACON in table 4 results revealed that there was no significant (p>0.05) difference among treatment groups in crude protein of pigs fed on diets T_1 T_2 and T_3 (21.45, 21.45 and 23.01). Ash of pigs fed on diets T_1, and T_2 (1.45 and 1.45) is significantly different (p>0.05) and significant different in treatment T_3 with values of 1.20 respectively. Moisture of pig fed on diets T_1 (16.44) is not significantly different (p>0.05) and was compared with pigs fed on diets T_2 with values of 16.44 respectively, although there was significant different with treatment T_3 (19.44). Ether extract of pigs at treatment T_1 (5.06), T2 (5.06) and T_3 (4.86) were not significantly at (p>0.05). Dry matter was also significantly (p<0.05) in pigs fed T_1 and T_2 with a value of (83.56 and 83.56) but there was significant different with treatment T_3.

Table 4 Proximate composition of BACON

Parameter	T1 Control	T2 Millet hulls	T3 Rice offal	SEM	P-value
Crude protein	21.45	21.45	23.01	0.68	0.25
Ash	1.45^{a}	1.45^{a}	1.20^{b}	0.13	0.38
Moisture	16.44^{b}	16.44^{b}	19.44^{a}	0.88	0.08
Ether extract	5.06	5.06	4.86	0.06	0.13
Dry matter	83.56^{a}	83.56^{a}	80.56^{b}	0.67	0.31

Mean bearing different superscript on the same row differ significantly at (p< 0.05)

PH AND MINERAL COMPOSITION OF BACON

PH and mineral composition of BACON in table 5 results revealed that there was significant (p>0.05) difference among treatment groups in pH of pigs fed on diets T_2 and T_3 (5.12 and 5.67) but there was no significant difference between treatment 1 and treatment 2. Potassium of pigs fed on diets T_1, T_2 and T_3 (212.45, 211.45 and 211.45) were no significantly different (p>0.05). Calcium of pig fed on diets T_1, T_2 and T_3 (12.45) is not significantly different (p>0.05). Iron of pigs at treatment T_1 (0.69), T2 (0.69) were not significantly at (p>0.05) but differ with treatment 3 with a value of 0.89. Phosphorus was also no significantly different (p<0.05) in pigs fed T_1 T_2 and T_3 with a value of (215.78, 215.78 and 213.67).

Table 5 pH and mineral composition of BACON

Parameter	T1 Control	T2 Millet hulls	T3 Rice offal	SEM	P-value
pH	5.12^{b}	5.12^{b}	5.67^{a}	0.10	0.01
Potassium	211.45	211.45	211.45	0.86	1.00
Calcium	12.45	12.45	12.45	0.47	1.00
Iron	0.69^{b}	0.69^{b}	0.89^{a}	0.01	0.00
Phosphorus	215.78	215.78	213.67	2.25	0.75

Mean bearing different superscript on the same row differ significantly at ($p < 0.05$)

PROXIMATE COMPOSITION OF SMOKED PORK SHOULDER

The proximate composition of smoked pork shoulder in table 6 results revealed that there was significant ($p>0.05$) difference among treatment groups in protein of pigs fed on diets T_1 and T_3 with a value of (20. 56 and 24.65) but there were no significant between treatment 1 and treatment 2. Moisture of pig fed on diets T_1 (18.44) is not significantly different ($p>0.05$) and was compared with pigs fed on diets T_2 with values of 16.71 respectively, although there was significant different with treatment T_3 (12.44). Ash of pigs fed on diets T_1, T_2 and T_3 (1.34, 1.33 and 1.22) is significantly different ($p>0.05$) respectively. Ether extract of pigs at treatment T_1 (5.11), and T2 (4.97) were not significantly at ($p>0.05$) but significantly different in treatment 3. Dry matter was also significantly ($p<0.05$) in pigs fed T_1 and T_2 with a value of (81.56 and 83.36) but there was significant different with treatment T_3.

Table 6 Proximate composition of smoked pork shoulder

Parameter	T1 Control	T2 Millet hulls	T3 Rice offal	SEM	P-value
Protein	20.56^{b}	21.80^{ab}	24.65^{a}	1.09	0.09
Moisture	18.44^{a}	16.71^{a}	12.44^{b}	1.04	0.01
Ash	1.34	1.33	1.22	0.10	0.68
Ether extract	5.11^{a}	4.97^{ab}	4.73^{b}	0.08	0.05
Dry matter	81.56^{b}	83.36^{b}	87.56^{a}	0.92	0.00

Mean bearing different superscript on the same row differ significantly at ($p < 0.05$)

PH AND MINERAL COMPOSITION OF SMOKED PORK SHOULDER

PH and mineral composition of sausage in table 7 results revealed that there was no significant ($p>0.05$) difference among treatment groups in pH of pigs fed on diets T_1, T_2 and T_3 (5.32, 5.29 and 5.11). Potassium of pigs fed on diets T_1, T_2 and T_3 (201.34, 209.11 and 212.45) were no significantly different ($p>0.05$). Calcium of pig fed on diets T_1, T_2 and T_3 (12.45) is not significantly different ($p>0.05$). Iron of pigs at treatment T_1 (0.70), T_2 (0.74) and T_3 (0.78) were not significantly at ($p>0.05$). Phosphorus was also no significantly different ($p<0.05$) in pigs fed T_1 and T_2 with a value of (211.56 and 212.48) but different from treatment 1 with a value (219.56).

Table 7 pH and mineral composition of pork shoulder

Parameter	T1 Control	T2 Millet hulls	T3 Rice offal	SEM	P-value
pH	5.32	5.29	5.11	0.07	0.16
Potassium	201.34	209.11	212.45	3.88	0.19
Calcium	12.43	12.51	12.45	0.58	0.99
Iron	0.70	0.74	0.78	0.02	0.15
Phosphorus	211.56b	212.48b	219.56a	0.93	0.00

Mean bearing different superscript on the same row differ significantly at ($p < 0.05$)

The proximate composition of smoked hindlimbs revealed that there was no significant ($p>0.05$) difference among treatment groups in crude protein of pigs fed on diets T_1 T_2 and T_3. Ash of pigs fed on diets $T_{1,}$ T_2 and T_3 is significantly different ($p>0.05$) and was higher compared with pigs fed on diets T_3 with values of 1.32 respectively. Moisture of pig fed on diets T_3 is not significantly different ($p>0.05$) and was compared with pigs fed on diets T_2 respectively, although there was significant different with treatment T_1. Ether extract of pigs at treatment T_1, T_2 and T_3 were not significantly at ($p>0.05$). Dry matter was also significantly ($p<0.05$) in pigs fed T_1 but similar to T_2 and T_3. pH and mineral composition of smoked hindlimb revealed that there was significant ($p>0.05$) difference among treatment groups in pH of pigs fed on diets T_2 and T_3 (5.44 and 5.12) but there was no significant difference between treatment 1 and treatment 2. Potassium of pigs fed on diets T_2 and T_3 were no significantly different ($p>0.05$) but significantly different with treatment 1 with a value 200.32 respectively. Calcium of pig fed on diets T_1, T_2 and T_3 is not significantly different ($p>0.05$) respectively. Iron of pigs at treatment T_1, T2 and T3 (0.76) were not significantly at ($p>0.05$). Phosphorus was also no significantly different ($p<0.05$) in pigs fed T_1 and T_3 but different to T_2. The proximate composition of BACON revealed that there was no significant ($p>0.05$) difference among treatment groups in crude protein of pigs fed on diets T_1 T_2 and T_3. Ash of pigs fed on diets $T_{1,}$ and T_2 is significantly different ($p>0.05$) and significant different in treatment T_3 with values of 1.20 respectively. Moisture of pig fed on diets T_1 is not significantly different ($p>0.05$) and was compared with pigs fed on diets T_2 with values of 16.44 respectively, although there was significant different with treatment T_3. Ether extract of pigs at treatment T_1, T2 and T_3 were not significantly at ($p>0.05$). Dry matter was also significantly ($p<0.05$) in pigs fed T_1 and T_2 but there was significant different with treatment T_3. pH and mineral composition of BACON revealed that there was significant ($p>0.05$) difference among treatment groups in pH of pigs fed on diets T_2 and T_3 but there was no significant difference between treatment 1 and treatment 2. Potassium of pigs fed on diets T_1, T_2 and T_3 were no significantly different ($p>0.05$). Calcium of pig fed on diets T_1, T_2 and T_3 is not significantly different ($p>0.05$). Iron of pigs at treatment T_1, T2 were not significantly at ($p>0.05$) but differ with treatment 3. Phosphorus was also no significantly different ($p<0.05$) in pigs fed T_1 T_2 and T_3. The proximate composition of PORK SHOULDER revealed that there was significant ($p>0.05$) difference among treatment groups in protein of pigs fed on diets T_1 and T_3 but there were no significant between treatment 1 and treatment 2. Moisture of pig fed on diets T_1 is not significantly different ($p>0.05$) and was compared with pigs fed on diets T_2 respectively, although there was significant different with treatment T_3. Ash of pigs fed on diets $T_{1,}$ T_2 and T_3 is significantly different ($p>0.05$) respectively. Ether extract of pigs at treatment T_1, and T2 were not significantly at ($p>0.05$) but significantly different in treatment 3. Dry matter was also significantly ($p<0.05$) in pigs fed T_1 and T_2 but there was significant different with treatment T_3. pH and mineral composition of smoked pork shoulder revealed that there was no significant ($p>0.05$) difference among treatment groups in pH of pigs fed on diets T_1, T_2 and T_3. Potassium of pigs fed on diets T_1, T_2 and T_3 were no significantly different ($p>0.05$). Calcium of pig fed on diets T_1, T_2 and T_3 is not significantly different ($p>0.05$). Iron of pigs at treatment T_1, T_2 and T_3 were not significantly at ($p>0.05$). Phosphorus was also no significantly different ($p<0.05$) in pigs fed T_1 and T_2 with a value of but different from treatment 1. In terms of proximate composition of smoked pork shoulder, the highest percentage moisture ($p\leq0.05$) was recorded by smoked pork shoulder of T_1 (18.44). Blade, (2012) reported a highest amount of moisture at 72.84% which is contrary to what is obtained in this study. Crude protein content among the cuts ranged from 20.56 to 24.65g/100g which varied significantly within the cuts, Blade, (2012) had the highest protein content at 28.02 g/100 g significantly higher than this study. Phosphorus had the highest mineral content of 211.56-219.56, this finding is contrary to Jodie, 2012 who reported a lowest phosphorus mineral content at 21.10, 0.91, 254. 50. Moisture content obtained from the smoked hind limb ranged from 12.44% to 17.24%. The high values of moistures obtained in the smoked hind limb in this study suggest a faster rate of likely food deterioration. The observation suggests therefore, a low shelf-life. Higher moisture contents in smoked hindlimb promote the growth of micro-organism and enzymes which lead to food spoilage (Lutz and prytulski, 2008). Moisture and dry matter contents of smoked hindlimb were higher in hams made from this study with a value of 12.44-17.24 for moisture while 82.76-87.56 for dry mater. These findings is contrary to Seong *et al.* (2008) who reported that moisture, and dry matter contents of the muscles biceps femoris from cooked dry-cured ham were 66.9%, 7.3%, and 22% respectively. Fuentes *et al.,* (2014) observed that moisture and dry matter content of the muscle biceps femoris from dry-cured hams produced from crossbred ranged from 48% to 51% and from 5.7% to 7.1%, respectively. PH, potassium and phosphorus content are believed to be one of the most crucial qualities of smoked hindlim where the results recorded for this study of pH is 5.12-5.44, potassium has recorded a value of 200.32-212.50 and phosphorus recorded a value of 214.76-234.87. Jiménez-Colmenero *et al.*, (2010) mentioned that the higher the pH, potassium and phosphorus content, the greater the acceptability of hams. Similar values were found for pH, potassium and phosphorus hams by Jin *et al.* (2012) who reported a value of pH is 5.10-5.40, potassium has recorded a value of 200.00-212.00 and phosphorus recorded a value of 214.70-234.80. Proximate composition of BACON each location within the belly has a dry matter range from 80.56-83.56. This disagrees slightly with observations of Trussell *et al.*, (2011) who reported the lowest dry matter content variability of proximate composition of (equivalent to zones 2-4 in his study). PH has a value of 5.67-5.12 while iron has a value of 0.69-0.89, this finding is contrary to Nisar *et al.,* (2010) who reported a models formulated with 5 and 15% pH and iron resulted in a 4% increase in cook yields with leaner patties as well as a difference in dimensional shrinkage of 76% between the patty formulations.

Conclusion

Based on the result obtained from this experiment, it was therefore concluded that rice offal and millet hulls have beneficial effect on the meat quality (processed pork cuts) and could be adapted as a replacement for maize offal in order to minimize cost of production and to enhance nutritive composition of pork products.

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