POTENTIAL AND NUTRITIVE EVALUATION OF PIG HOOF MEAL AS DIETARY PROTEIN FEED INGREDIENT

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Abstract: There has been an increase in the number of pigs slaughtered worldwide due to population growth. Pig Hoof, a non-edible slaughter-house waste, disposal is generating concern for the authorities and utilizing this by-product which has remained hitherto unused is the thrust of this study. Pig hoof was collected from the slaughter house and analysed for its nutritional content according to standard method. Analysed parameters were Crude protein 83.09±1.46, Fat 1.04±0.01, Fibre 9.04±0.16, Ash 6.53±0.12 and metabolisable energy 3159.40±54.52 KJ kg^{-1}. The essential amino acid profile revealed Leucine as highest 6.71 g/100g, Histidine least 0.89 g/100g and tryptophan was below detectable limit while the non-essential amino acid Glutamic acid was highest 13.02 g/100g and Cysteine 0.66 g/100g least. The macro mineral content of pig hoof showed that Magnesium 1.22±0.23%, Phosphorus 0.83±0.01%, Sodium 0.37±0.02%, Calcium 0.30±0.01%, Potassium 0.23±0.01% while the micro mineral content was highest in Iron 2310±5.19 mg/kg and least in Copper 7.55±0.35 mg/kg.

Keywords: Keratin, dietary potential, monogastric, pig-hoof, waste

Introduction

Pigs are monogastric animals of the family *Suidae* (TAS, 2006), prolific in reproduction with the ability to convert feed and household waste to weight in a short period of time (5-7 months) (Taiganides, 1992). Different breeds are slaughtered at abattoirs locally (Aiki-Raji, 2018). Cromwell (2006) stated that in 2003 there were 70,130 pig farmers in the United State and over 1,000 pig farms in a farm settlement in Nigeria (Omotosho *et al.,* 2016). Pig hoof is inedible for human consumption and available from slaughter houses in large quantities. There is need to emphasise on it as feed ingredient due to daily increase in availability as a result of port/bacon dietary needs and industrial applications of pigs.

Yield of inedible product from pig can be high (Jayathilakan *et al.,* 2012) after slaughter due to removal of keratin based product with use of hot water (TAS,2006) and some of these have found use in industrial application for gelatin and collagen production (Mekonnen, 2018). Large quantities of pigs are slaughtered annually worldwide (1.5 billion) (Sanders, 2018); in Africa (29 million) and Nigeria (6.2 million) (FAOSTAT, 2017b). Jayathilakan *et al.* (2012) reported waste production from pigs (2.3kg/head); 4% of the pig weight. Edia-Asuke (2014) reported average slaughter of 7 pigs/day in the North (Nassarawa State) while Omotosho *et al.* (2016) reported slaughter of 181 pigs/day in South-Western states of Nigeria. This is due to the increase in human population that needs to satisfy meat consumption requirements (Akinfolarin and Okubanjo, 2010).

Martínez-Alvarez *et al.* (2015) stated that non-utilization or underutilization of animal by-products leads to loss of potential revenues and increasing cost of disposal of these products. These waste has embedded in it useful protein and amino acid locked up in keratin form (Onifade *et al.,* 1998).Wagner and Elvehjem (1943) reported the use of swine hoof to replace fishmeal and meat meal, and Slinger *et al.* (1944) stated that the combination of calf and swine hoof can only be used moderately in poultry nutrition while Agren (1951) further studied the nutrient content of pig hoof. Justification for this study is that Pig Hoof Meal (PHM) can be produced and is of no economic value presently. Acute shortage of fish meal can be alleviated by incorporating this non-conventional feed resource in livestock nutrition. PHM potential and awareness be stressed due to human nutritional demand for pork and bacon. Making use of this inexpensive feedstuff will ameliorate the demand and emphasis being placed on other forms of expensive animal protein. Data on the nutritional composition dates back to decades. This study therefore assesses the potential of generating and nutritional composition of PHM.

Materials and Methods

Secondary data of pigs slaughtered were obtained from the Abattoir Service Department (ASD) in Ogun, Oyo and Lagos State. Adult slaughtered pigs (n=108) were de-hoofed of the claw by immersion in hot water for 5 minutes at boiling point (100^{o}C). Sterilization was carried out in an autoclave for 10 min at 150 psi and oven dried at 50^{o}C for 8 hours before pulverizing with locally fabricated burr mill (Sule and Odugbose, 2014). Proximate analysis was according to AOAC (2006) and metabolizable energy calculated according to Pauzenga (1985). Mineral analysis was determined by wet ashing with perchloric acid and nitric acid and macro and micro element separated using atomic absorption spectroscopy (AAS Model 210/211 VGP) at the Department of Agronomy, University of Ibadan, while amino acid analysis was by the use of TSM anlyser (Applied Biosystems PTH Model 120A) at the University of Jos. Descriptive statistics using IBM SPSS 20 was used and results reported as means ± SE.

Results and Discussion

Slaughter statistics from three South Western States (Table 1) with an average of two, seven and nineteen pigs slaughtered daily in Ogun, Oyo and Lagos State respectively. Result is similar with Edia-Asuke (2014) for a slaughter slab but different from Omotosho *et al*. (2016) of 66,040 slaughtered pigs per year in the same study area. This is as a result of real time data collection by Omotosho *et al*. (2016) as data used in this study were secondary data from government agencies. Egbunnike and Ikpi (1990) and Blench (1999) reported that slaughter statistics from secondary data represents underestimation.

Table 1: Slaughtered pigs in three South-Western States, Nigeria 2004 – 2013

Year	Lagos State	Ogun State	Oyo State
2004	N/A	141	8,446
2005	N/A	N/A	3,632
2006	N/A	229	5,236
2007	N/A	248	1,155
2008	13,649	850	868
2009	11,918	809	N/A
2010	8,672	1,466	1,751
2011	7,764	811	1,364
2012	7,625	715	1,054
2013	5,870	481	2,208

Adapted Sources: Lagos State Abattoir Service Department (ASD) (2013), Ogun State Abattoir Service Department (ASD) (2013), Oyo State Abattoir Service Department (ASD) (2013)

Records from Food and Agricultural Organisation (FAO) revealed an increase in pig population and slaughtered head in Sub-Saharan Africa. For ease of assessment and quantification, Nigeria has the highest pig population and slaughtered head in Africa according to FAOSTAT (2017a; 2017b). The pig population for Sub-Saharan Africa was under reported by Otte and Chilonda (2002) as consideration of some countries were omitted. The pig population increased over the years (Table 2) with an increase in slaughtered head over the same period (Table 3). This can be connected to the population increase in Africa with a growth rate of 2.8% (Otte and Chilonda, 2002). From this study Africa produced over 727 metric tons of pig hoofs for the year 2017 according to FAOSTAT data, which were waste. This is in line with Gonzalo *et al*. (2016) that reported collection of pig hooves along with the hair (16 metric tons). This study found out that quantity of hoof are generated at abattoirs and this supports the findings of Karthikeyan *et al*. (2007) that keratin materials are produced in large amount and are wasting away at dumpsites.

Table 2: Pig population in Sub-Saharan Africa (1999 and 2016)

Region/country	1999	2016	Region/country	1999	2016
Central Africa			Southern Africa		
Cameroon	1000000	5694624	Angola	800000	3180401
Central African Republic	649400	1106923	Botswana	4000	4194
Congo, Dem. Republic	1100086	980323	Lesotho	103700	58446
Congo, Republic	54000	103400	Madagascar	980000	1669000
Gabon	212000	223488	Malawi	444381	3644100
E/Guinea	5900	6844	Namibia	18731	89380
Subtotal	3021386	8115602	South Africa	1530899	1512453
East Africa			Swaziland	31000	35599
Burundi	206276	333925	Zambia	324000	1374137
Ethiopia	25000	34975	Zimbabwe	278811	304265
Kenya	317115	504395	Subtotal	4515522	11871975
Rwanda	159625	1165225	West Africa		
Somalia	3800	3763	Benin	194511	466000
Tanzania, United Rep.	446338	516912	Burkina Faso	1288102	2350430
Uganda	1520000	2626405	Chad	21000	33931
Subtotal	2678154	5185600	Côte d'Ivoire	284569	343356
African Islands			Gambia	14000	6675
Cape Verde	200000	87121	Ghana	332000	730000
Mauritius	10500	24224	Guinea	53604	112256
Reunion	77333	68496	Guinea-Bissau	345000	406463
St. Helena, Ascencion	626	622	Liberia	120000	344959
Sao Tome/Principe	2100	41247	Mali	56430	83174
Seychelles	17444	5220	Niger	39000	42523
Subtotal	308003	226930	Nigeria	4853487	7488631
North Africa			Senegal	240000	409047
Algeria	5700	4872	Sierra Leone	52000	52364
Egypt	29000	9824	Togo	375000	493477
Morocco	8000	7962	Subtotal	8268703	13363286
Tunisia	6000	5511			
Subtotal	48700	28169	Total Africa	18840468	38791562

Adapted source: FAOSTAT (2017a)

Table 3: Slaughtered pig head in Sub-Saharan Africa (1999 and 2016)

Region/country	1999	2016	Region/country	1999	2016
Central Africa			Southern Africa		
Cameroon	605000	783406	Angola	440000	1750954
Central African Republic	390000	633917	Botswana	8600	18006
Congo, Dem. Republic	620590	531604	Lesotho	87000	55769
Congo, Republic	30250	37206	Madagascar	570000	916033
Gabon	115000	117779	Malawi	405000	4898588
E/Guinea	3050	3601	Mozambique	2016000	2061922
Subtotal	1763890	2107513	Namibia	24000	107638
East Africa			South Africa	2145000	3045679
Burundi	40000	123450	Swaziland	26300	27184
Ethiopia	28800	40125	Zambia	240000	999859
Kenya	158301	313600	Zimbabwe	232000	265550
Rwanda	70000	255283	Subtotal	6193900	14147182
Somalia	2300	2068	West Africa		
Tanzania, United Rep.	312000	368847	Benin	87500	207585
Uganda	1250000	2103017	Burkina Faso	775861	1298072
Subtotal	1861401	3206390	Chad	16000	25144
African Islands			Côte d'Ivoire	177964	201733
Cape Verde	140000	66902	Gambia	9000	6672
Mauritius	10042	11641	Ghana	266000	582164
Reunion	150000	179819	Guinea	33620	62508
St. Helena, Ascencion	1321	1594	Guinea-Bissau	266000	284086
Sao Tome/Principe	1680	9534	Liberia	100000	291458
Seychelles	20865	5965	Mali	45150	57408
Subtotal	323908	275455	Niger	31000	33198
North Africa			Nigeria	3400000	6139547
Algeria	3200	2846	Senegal	179692	296858
Egypt	68000	16649	Sierra Leone	39500	38512
Morocco	12000	12434	Togo	206250	306319
Tunisia	3100	2587	Subtotal	5633537	9831264
Subtotal	86300	34516	Total Africa	15862936	29602320

Adapted source: FAOSTAT (2017b)

In this study a total of 108 slaughtered pigs produced 2.66 kg of pig hoof meal (Table 4). With the hoof mean weight 24.58 and 41 slaughtered pigs producing 1 kg of PHM. Similar report has been reported by Scaria (1989) 0.6 kg horn/hoof from a slaughtered Cattle.

Table 4: Weight in relation to production of one kilogramme of pig hoof meal

(n=108)	Minimum weight (g)	Maximum weight (g)	Mean±SE
Mean average	17.96	31.29	24.58±0.25
Number pigs/kg meal	56.00	32.00	41.00

Table 5: Proximate analysis of pig hoof meal

Proximate	%
Crude Protein	83.09±1.46
Crude fat	1.04±0.01
Crude fibre	2.49±0.16
Ash	6.53±0.12
Moisture content	9.64±0.21
Metabolisable energy (Kcal)	3159.40±54.52

The nutritive value of pig hoof meal (Table 5) had high protein and low in fat. The protein content of PHM in this study was lower to the values of Cattle hoof and horn meal 93.3% and higher than lamb raw hooves reported by AFRIS/Feedepedia (2012) while minimal crude fibre was analysed for and in contrary, AFRIS/Feedepedia (2012) which reported no crude fibre in analysis for cattle and lamb and ash content were higher than that of cattle horn/hoof but lower than lamb hooves 15.8%. Reported crude proteins of keratin from different sources were higher than in this study by researchers (Wagner and Elvehjem, 1943) 90.63%; Agren (1951) 93.5%; Nordheim and Coon (1984) 95.6% and Assis *et al*. (2017) 91.67%) this may be as a result in keratin composition of different animal species, the processing methods employed in obtaining the meal as well as the analytical method.

The macro and micro mineral content analysed contained high amount of magnesium and low quantity of potassium (Table 6). The low calcium is as a result of no bony structure in the declawed hoof which is purely the keratin structure and this differs from Bhagat (1994) which made use of the whole hoof without de-hoofing and AFRIS/Feedepedia (2012) for horn and hoof keratin from ruminant. The mineral content of Ca, K, and Zn were lower than the values reported by Assis *et al*. (2017) for buffalo hooves (Ca 8.13; K 3.47; Zn 0.81) while P and Cu in this study was higher than reported by Assis *et al*. (2017) (P 3.74; Cu 0.31).The difference is as a result of animal species difference and the nutrition of the species.

Table 6: Mineral content profile of pig hoof meal

Mineral	Result
Phosphorus (%)	0.83±0.01
Calcium (%)	0.30±0.01
Magnesium (%)	1.22±0.23
Potassium (%)	0.23±0.01
Sodium (%)	0.37±0.02
Manganese (mg/kg)	9.50±0.29
Iron (mg/kg)	2310±5.19
Copper (mg/kg)	7.55±0.35
Zinc (mg/kg)	76.45±0.03

Table 7: Amino acid profile of pig hoof meal

Amino acid	g/100g
Arginine	3.79
Histidine	0.89
Isoleucine	3.08
Leucine	6.71
Lysine	3.18
Methionine	1.92
Phenylalanine	2.30
Threonine	3.88
Trypthophan	BDL
Valine	3.62
Alanine	3.41
Aspartic acid	7.63
Cysteine	0.66
Glutamic acid	13.02
Glycine	4.23
Proline	3.65
Serine	5.35
Tyrosine	3.27

BDL = Below Detectable Limit

The amino acids that appeared limiting in PHM are histidine, cysteine and tryptophan (Table 7). Agren (1951) analysed PHM for amino acid using three methods being the first amino acid investigation of PHM which was compared to cattle horn amino acid. The amino acid content in this study showed variations from the three results of analysed pig hoof, leucine and methionine were higher than Agren (1951) results (3.2-4.8; 0.8-1.3) while phenylalanine, threonine, aspartic acid, glutamic acid and tyrosine were in range of Agren (1951) (1.8-3.4; 3.1-4.2; 6.9-10.5; 10.5-18.0;2.6-6.8) respectively. The value of methionine in this study was higher than 0.8 reported by Marshall and Gillepsie (1977) for sheep hoof while sheep hoof was superior to PHM in other amino acid content. Lysine in this study falls within the range reported for feather and hair meal (Nordhiem and Coon, 1984). Tryptophan an essential amino acid was not detected and this confirms its none presence as reported by (AFRIS/Feedepedia, 2012) or at minimal level in other forms of keratin Agren (1951) 0.5-0.6; and Summers and Leesons (1978) 0.48. Aspartic acid in this study similar to AFRIS/Feedepedia (2012) 7.9. The amino acid requirements of the African Catfish were met in leucine, isoleucine, valine and threonine. While the values of tyrosine, glutamic acid and serine were higher than fishmeal (AFRIS/Feedepedia, 2012) values and PHM inferior to the other amino acids. This indicates the need to supplement the amino acid to meet the nutritional need of the species in question for optimal growth and performance as reported by Summers and Leesons (1978); Falaye (1982) and Wilson (2003).

Conclusion

Presently pig hooves have no use and economical value at the abattoirs, as they are regarded as waste to be disposed-off at a cost. This study concludes that Pig hoof is available locally in enough quantity that can justify its utilization by the feed industry. Its nutritive value compares to that of fishmeal and other rich protein source of animal origin making it a valuable non-conventional feed resource for livestock nutrition.

Conflict of Interest

Authors have declared that there is no conflict of interest reported in this work.

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