EVALUATION AND POTENTIAL GENERATION OF GOAT HOOF AND HORN WASTE AS PROTEIN FEEDSTUFFS

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ABSTRACT

Small ruminants especially goat is relished for its taste and aroma in human nutrition with an increase in annual consumption figures. Inedible waste especially keratins generated from slaughter of these animals are viewed as environmental pollutant. Further economic utilisation of the enourmous waste will ameliorate some of the problems of its disposal. Goat of average size 25-50kg was sampled for hoof (n=556) and horn (n=125) from two slaughter slabs with an average daily slaughter of 84 goats including 12 purposively sampled restaurants undertaken by21 buthchers in the study area. Mean average weight of hoof and horn are 28.89±0.18; 21.62±0.69 respectively with an annual production 21.6 tons hoof and 12.3 tons horn. Proximate analysis revealed the hoof to be higher in value than the horn: protein (90.84±0.11; 83.39±0.36), fat (2.48±0.04; 2.36±0.02), fibre (0.71±0.03; 0.29). Tryptophan was not detected while cysteine, histidine and methionine are limiting in the samples. Mineral analysis indicated iron, copper, manganese and potassium to be high in goat hoof (426mg/kg; 8.40mg/kg; 5.50mg/kg; 0.19%), calcium, phosphorus, magnesium and zinc (0.09%; 0.88%; 0.40%; 61.45mg/kg) high in horn while sodium was not different among samples. The relative abundance and nutritional value of goat hoof and horn makes it a potential feedstuff and need to utilise it in livestock nutrition to assess its potential and effect on growth on fed livestock need be encouraged.

Keywords: Goat, Inedible-byproduct, Keratin, Slaughter-waste.

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Introduction

Increase demand for goat meat consumption, health, festival and religious rights (Okpebholo & Kahan, 2007) has increased small ruminant consumption especially of the *Capridae* family over the years. Sanders (2018) reported global goat slaughter at 450 million herds in 2016, while FAOSTAT (2017) reported the producing animal and slaughter of goat in Nigeria as 25million, the fourth highest in the world (Sanders, 2018). This does not take into account slaughter outside the abattoirs. The alternative use to which goats are put to in the production of hides and skin for the tanning industry has also increased the value slaughtered (Felsner & Schmel, 2002). Kumar *et al*., (2017) million tons of hoof materials are wasted and degraded in land fills. Ezeoha & Ugwuishiwu (2011), Olawuni *et al*., (2017) stated that horn and hoof are pollutants while Onifade *et al*., (1998); Makinde *et al*., (2008) and Alao *et al*., (2017) reported prospects of slaughter waste usage especially keratin as livestock feed.

Goat hoof keratin can be used in medical field for wound healing and tissue regeneration. Using byproducts for the production of fish feed has particularly good prospects (Coutand *et al*., 2008; in Saanick *et al*., 2013).Keratin byproducts of animal origin are rich sources of protein, amino acid and minerals (Falaye & Sule, 2020). The inedibility of some animal byproduct for human is as a result of its physical and chemical characteristics which are unusual (Deng-Cheng, 2002) which has led to the production of inedible waste from meat processing and environmental pressure. With the rendering industry, these are being converted into rich protein feed stuff now available in the international market worldwide. Scaria (1989) stated economic importance of *animal by-products utilization and as* a source of wealth (Adewunmi *et al*., 2011) when processed into materials that can be further utilised in livestock nutrition with little organic carbon footprint. Hoof and horn is being used as organic fertilizer in soil nutrition (Penhallegon, 2003)

The bovidae possessed horn (Tombolato *et al*., 2010). Horns and hoof are composed of keratin protein (Tombolato *et al*., 2010; Sharma & Gupta, 2016). Cote *et al*., (1998); McDough *et al*., (2006) reported that appreciable growth of goat horn is achieved by the second year in doe and buck. While the hoof growth rates of the European Roe Deer(*Capreolus capreolus*) was reported at 0.12mm/day (Hafner*et al*., 2017).

Keratinolytic effect on goat hoof has been examined (Akinyele & Owolabi, 2016; Adamu *et al*.,2019) as a waste abatement measure. The utilisation of keratin in animal nutrition relative to abundance in nature is small (Lei, 2010) and goat hoof and horn has been used in fish nutrition (Bhagat, 1994). Information is lacking on the nutritional value of goat hoof and horn meal as feed resources hence the study.

Materials and methods

Samples of goat hoof and horn were collected from the Kara and Isale-Oko Slaughter slabin Sagamu Local Government Area of Ogun State. Daily slaughter was monitored for 30 days to ascertain the average slaughter per month and the number of butchers involved in goat meat marketing also ascertained. Purposive sampling of 12 restaurants engaged in goat meat dishes was also undertaken. Samples was transported to the Nutrition laboratory College of Agricultural Sciences, Ayetoro. Samples of goat hoof and horn were washed off hair and rumen digesta with borehole water, the horn and hoof was bolied in water at boiling point to remove the bony structure of the horn ; attached sole of the hoof (AFRIS, 2012) and sun dried for twenty-one days. Dried samples was weighed using Labtech BL3002 weighing balance. Samples were milled using fabricated local burr mill grinder (Sule & Odugbose, 2014). Milled samples of goat hoof and horn were analysed for proximate (AOAC, 2006), amino acid profile analysis (Dedeke *et al*., 2010) and mineral content analysis was as described by Falaye & Sule (2020). Limitation of slaughter slabs considered the metropolitness of Sagamu township excluding Ogijo township. Also horn sample collection limitation was as a result of the depithing undertaken hence the lower sample size relative to hoof sample size. Statistical analysis of data in the study was by the use of descriptive statistics and students independent T Test (IBM SPSS version 20) and results expressed as mean ± standard error (SE).

Results

The goat breed slaughtered at the slabs and restaurants was the Sokoto Red with average weight of 25kg-50kg. The total number of butchers involved in slaughtering was26. Daily slaughter at the two slabs was65 goats/day; while average slaughter at the twelve restaurants was19 goats/daywith average of 26 slaughter days in a month. Total goat slaughtered daily in Sagamu township estimated at 84 goats which was undertaken by 21 buthchers and slaughter can extend to late hours in the evening depending on customers demand. Some of the buthchers also render slaughter services to the restaurants at a fee. A total of 125pairs of goat horn and 556 quadruple pairs of goat hoof were sampled for the hoof and horn. The samples waste weighed produced 16065.76kghoof meal and 2702.73kg horn meal (Table 1). Hoof mean weight was higher than horn mean weight.

Table 2 showed the proximal analysis of the hoof and horn samples to be significantly different ($P<0.05$) in crude protein, ash, fibre, moisture content and Nitrogen Free Extract (NFE) while the fat content was not different significantly in the analysed samples.

Table 3 revealed the amino acid analysis showed slight significant difference (P<0.05) in arginine, threonine, isoleucine, leucine, phenylalanine, aspartic acid, proline, alanine, cysteine and glycine, while tryptophan was not detected after been analysed.

Table 4 macro and micro mineral content of samples showed that phosphorus, calcium and zinc were highest in goat horn; while potassium, manganese, iron and copper were highest in goat hoof.

Table 1: Production of Goat hoof and horn meal.

	Animal number (n)	Min.(g)	Max. (g)	Mean± S.E	Total sample weight (kg)	Production n per kg	Annual Production (ton)
Goat hoof	556	19.45	44.28	28.89±0.18	16065.76	35	21.6
Goat horn	125	8.66	40.86	21.62±0.69	2702.73	47	12.3

Table 2: Proximate analysis of Goat hoof and horn

		Mean ± SE
Protein %	Goat Hoof	90.84±0.11
	Goat Horn	83.39±0.36
Fat %	Goat Hoof	2.48±0.04
	Goat Horn	2.36±0.02
Ash %	Goat Hoof	6.55±0.14
	Goat Horn	7.37±0.19
Fibre %	Goat Hoof	0.71±0.03
	Goat Horn	0.29±0.03
Moisture %	Goat Hoof	6.49±0.09
	Goat Horn	5.03±0.12
NFE %	Goat Hoof	0.00±0.00
	Goat Horn	1.58±0.62

Table 3 : Amino acid profile of Goat hoof and horn

EAA (g/100g)	Goat hoof	Goat horn
Lysine	3.71	3.98
Histidine	1.09	1.09
Arginine	8.26	8.77
Threonine	4.49	4.33
Valine	4.91	4.97
Methionine	2.03	2.14
Isoleucine	3.27	3.01
Leucine	7.00	7.53
Phenylalanine	2.84	3.19
Tryptophan	BDL	BDL
NEAA		
Aspartic acid	7.01	8.00
Serine	5.78	5.62
Glutamic acid	12.56	12.87
Proline	4.67	5.28
Alanine	4.17	4.70
Cysteine	0.73	0.91
Tyrosine	3.78	3.78
Glycine	5.04	5.18

EAA: essential amino acid; NEAA: Non -essential amino acid; BDL: Below detectable limit

Table 4 : Mineral content of Goat hoof and horn

	P(%)	Ca(%)	Mg(%)	K(%)	Na(%)	Mn(mg/kg)	Fe(mg/kg)	Cu(mg/kg)	Zn(mg/kg)
Goat hoof	0.77	0.06	0.38	0.19	0.35	5.50	426.00	8.40	37.10
Goat horn	0.88	0.09	0.40	0.15	0.35	3.50	31.20	6.40	61.45

Discussion and Conclusion

Slaughter statistics of goat has been reported to outstrips that of other ruminants in Nigeria (Otte & Chilonda, 2002; Felsner & Schmel, 2002; Sanders,2018).Opara *et al.,*(2005) reported 44average daily slaughtered goats (a.d.s.g) for Akwa Ibom State; Chukwu *et al.,* (2011) 382a.d.s.g. from 9 abattoirs Niger State; 64-74a.d.s.g in Bauchi abattoir (Abubakar & Burrah, 2013); 38a.d.s.gfor an abattoir in Ghana (Twumasi *et al.,* 2016). In 2013, 52a.d.s.g was reported for Ogun State of which 8a.d.s.g was for the study site (ASD 2013a), Oyo State 55a.d.s.g (ASD 2013b) and Lagos State 172 a.d.s.g which increased to 200a.d.s.g in 2016 (ASD 2016). The result for Lagos State is line with Akinfolarin & Okubanjo

(2010) who reported fluctuating figures over a decade in Lagos State. Goats slaughtered in the study area was above the values reported by ASD (2013a) for Sagamu and also above values cited in literatures for slaughter slabs. This high a.d.s.g value can be adduced to the eliteness and large population of the areas cited by authors as this was witnessed in the study area which is also an economic nerve centre for Ogun State.

Error in analysis was taken into consideration by sampling larger number of animals. The number of goat sampled for horn and hoof in this study was higher than Peres-Casanova & Kucherova (2013) who sampled twenty seven goats for horn and Sule *et al.,* (2020) that sampled 108 pigs for hoof. Sule *et al.,* (2020) analysed pig hoof weight to be 24.58g, while a kilogramme g hoof meal was produced by 41 pigs. Scaria (1989) projected annual cattle horn and hoof production at 18ton respectively frm 50 slaughtered cattle/day. An annual tonnage of 21.6 ton/yr hoof and 12.3ton/yrhorn was envisaged in the study area. Kurbanoulu & Algur (2002) reported Ram horn from slaughter house in Turkey to be a significant waste product with 600tons produced annually. Global production of goat hoof and horn meal based on Sanders (2018) data yielded 371million metric tons (mmt) of goat hoof and 207mmt of goat horn. Projection will however vary based on the weight, size, condition at slaughter, sex of slaughter animal and different goat breeds scatered worldwide.

Protein content of hoof and horn meal have been reported to contain high nitrogen: 14.96% Agren (1951); 12.98%-15.10% Owen *et al.,* (1953b); 9%-14% Penhallegon (2003); 16.46%-17.36% Sule (2014);Kakkar *et al.,* (2014) when lyophilized 13.30%-16.70%; hoof of buffalo 14.68%; 14.09% Assiss *et al.,* (2017); Sasidharan & Sunilkumar (2019) and pig hoof 13.28% Sule *et al.,* (2020). The hoof protein 69.5% for lamb as reported by Gohl (1981) and AFRIS (2012) were lower to that of goat hoof. Falaye & Sule (2020) report on crude protein of raw cattle hoof similar to goat hoof. Fat in goat hoof was higher than in raw cattle hoof while ash and crude fibre in goat hoof were higher than for ruminant keratin (Kida *et al.,* 1995; Sasidharan & Sunilkumar, 2019; Falaye & Sule, 2020). Sule *et al.,* (2020) fat in pig hoof is however low to this study. Low fibre in goat hoof and horn analysis corroborates Owen *et al.,* (1953a) and Sasidharan & Sunilkumar (2019) of keratin containing minimal fibre.

Slinger *et al.,* (1944) reported difference in amino acid of horn and hoof meal. The amino acids of cattle horn and hoof (AFRIS, 2012)were superior in values than goat hoof and horn. Goat hoof and horn was higher in value than thirteen analyte of pig hoof amino acid (Sule *et al.,* 2020); nine analyte slightly compared to cattle hoof (Falaye & Sule, 2020) while trypthophan loss was in accordance with literatures on keratin materials (*Marshall a& Gillespie, 1977*; Zoccola *et al.,* 2009). However, tryptophan in analysed pig hair was reported to be low (Summers & Lesson, 1978) and this indicated that tryptophan is present in analysed samples but lost in the process of hydrolysis employed in analysis according to Dalev *et al.,* (2007). Limiting amino acid that will require supplementation are histidine, cysteine and trypthophan and same was observed for pig hoof (Sule *et al.,* 2020). Amino acid limitation in feed can however be supplemented (Falaye, 1982) or compensated for by other feedstuff ingredient in the dietary composition.

Mineral are required for essential growth of living tissues both plant and animal. The phosphorus content observed for goat hoof and horn is lower to 8.75% (Gohl, 1981); 1.5-2.0% (Penhallegon, 2003); 9.41% (Žibutis *et al.,* 2012) for horn powder and 3.74% **(**Assiss *et al.,*2017) while similar trend was observed for calcium by the scientists. Sule *et al.,* (2020) reported similar results for phosphorus (0.83%), potassium (0.23%), sodium (0.37%) mineral content of pig hoof. The high iron and zinc content was similar to reported high values in Falaye & Sule, (2020) cattle hoof and Sule *et al.,* (2020) for pig hoof. These values point to the fact that the mineral content of goat hoof and horn can meet some of the nutritional mineral needs of livestock.

The slight variation observed in the analysis indicated that goat hoof and horn are similar in composition despite location in the animals body, this corroborates the findings of Tombolato *et al*., (2010) of structure and compositional similarity of hoof and horn material. Hoof and horn have been used in nutrition of livestock with variable results (Wagner & Elvehjem, 1943; Newell & Elvehjem, 1946; Bhagat, 1994) and as source of mineral nutrient in organic farming (Penhallegon, 2003). Its use as feedstuff with adequate processing to

remove fear of contamination (Brandelli *et al.,* 2015; Irshad *et al.,*2015; Oberthur, 2009) which will further improve environmental sanitation (Sharma & Gupta, 2016) is hereby advocated for.

This study concludes from the foregoing of the abundance and importance that should be placed in the utilisation of goat hoof and horn as a feedstuff ingredient capable of reducing environmental pollution pressure and as an income generating venture from collection to processing into meal for plant and animal nutrition. This will reduce the importation of rich protein ingredient of animal origin and chemical fertilizer.

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