



Chemical composition of differently processed Cattle Hoof meal Waste as Feedstuff Ingredient

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Abstract

Waste generation at slaughter from ruminant has led to environmental concerns. Processing slaughter house waste will reduce the problem of disposal and possible utilisation in livestock feed. Subjecting Cattle hoof meal to different processing methods can help in enhancing its nutritive value. Cattle hoof were obtained from the slaughter house; raw hoof was subjected to processing methods by boiling; chemical treatment with 10 % soda ash + boiling; fermentation treatment in water + boiling; 10 % wood ash treatment in water + boiling; autoclave treatment and samples analysed for proximate composition, amino acid profile and mineral content analysis according to standard methods. The hoof proximal analysis ranged 9.30 ± 0.06 % – 12.39 ± 0.01 % moisture content; 0.34 ± 0.01 % – 2.50 ± 0.12 % ash; 0.31 ± 0.01 % – 1.47 ± 0.02 % crude fat; 0.19 ± 0.02 % – 12.71 ± 0.15 % crude fibre and 85.27 ± 0.20 % – 90.74 ± 0.26 % crude protein in all samples. The amino acids profile of the hoof showed significant difference among treated samples. Tryptophan an essential amino acid was below detectable limit in all processed samples and raw hoof. The essential and non-essential minerals content showed significant difference ($P < 0.05$) among treatments with highest (Mg, Fe, K) in wood ash; (Cu) in raw hoof; (Ca, Na, P, Mn, Zn) in autoclaved samples. This study, suggest that Cattle hoof has the potential of being exploited as a source of animal protein for feed formulation in animal nutrition. This research concludes that the different processing methods affect the nutritive profiles of treated samples hence supplementation of limiting amino acids envisaged.

Key words: Slaughter-waste, Valorisation, Keratin, Cattle hoof.

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1. Introduction

The scarcity and increasing cost of animal and plant protein utilization in livestock nutrition, due to decreasing catch of capture fisheries from the wild and human population explosion competition for food of plant origin with livestock has generated concern for scientists. Providing a sustainable animal protein source for increased animal production from the abattoir and slaughter house is inevitable. The utilization of by-product of plant and animal origin has been widely researched (Devendra, 1985; Falaye, 1992). Slaughter house waste of poultry feather keratin (Falaye, 1982; Omitoyin, 1995) has been assessed for their nutrient value and their implication in fish nutrition. There has been an increase in meat consumption in Nigeria (Akinfolarin & Okubanjo, 2010) and slaughter cattle statistics in Africa (FAOSTAT, 2017) these slaughter generates inedible keratin by-products which are potential protein ingredients source. The poultry

feather keratin has been quantified to be enormous (Omitoyin, 1995) constituting waste and environmental health hazard.

Keratins are rich protein ingredients but digestibility has been a subject of controversy. Improving the digestibility of keratin has been achieved through various methods (Falaye, 1982; Omitoyin, 1995; Coward-Kelly et al., 2006; AFRIS, 2012). Hoofs are soft keratin (Tomlinson et al., 2004) with growth rate 0.215mm/d (Zazzo et al., 2007) and are now been processed for human consumption in England (Walsh, 2014) and in Rwanda (Asaba, 2015). Hooves are part of inedible animal by-product discarded (Kiyanjui & Noor, 2013) while its exploitation in value addition is less considered (Kakkah et al., 2014; Alao et al., 2017). It contains no anti-nutrient factor (Belewu et al., 2008) hence can find application in animal nutrition (Chojnacka et al., 2011).

There is dearth of information on the nutritive value of hoof keratin from the slaughtered Cattle. This study

therefore assessed the proximate, amino acid and mineral content of Cattle hoof keratin subjected to different methods of processing.

2. Materials and methods

Collection and processing of samples

This research was conducted at the University of Ibadan, Department of Aquaculture and Fisheries Management. Samples of hoof were collected from the University Slaughter slab. Sand sediment was washed off samples and sundried for fourteen days (Falaye, 1992). Cattle hoof were crushed to 4mm diameter by improvised plastic crusher. Crushed samples were milled using local burr mill grinder (Sule & Odugbose, 2014). Milled samples (200 g each) were subjected to Chemical treatment method with soda ash (10 % sodium ash for 60 hours at 20 °C) (AFRIS, 2012), fermentation treatment in water for 60hours (Sotolu, 2008), wood ash fermentation treatment (Adejumo et al., 2016) 10 % wood ash water for 60 hours, autoclave treatment only (Omitoyin, 1995) in autoclave machine Model YX-280A for 1 hour at 150 psi and raw unprocessed hoof (Owen et al., 1953a). All n = 5 samples were boiled for one hour (AFRIS, 2012) with the exception of autoclave treatment and oven dried at 50 °C for 8 hours.

Analytical procedure

Samples were analysed for proximate, crude protein determination was by Kjeldahl technique of digestion, distillation and titration process used in Nitrogen determination and multiplied by conversion factor (Protein % = Nitrogen Value in sample × 6.25). Fat determination was achieved by extraction method using petroleum ether for two and half hours in fat extraction machine, and calculated as (Fat % = (weight₂ of cup – weight₁ of cup × 100)/Weight of sample. Crude fibre was determined as the material left over from the digestion of sample in sulphuric acid and repeating the process in potassium hydroxide using a Fibretec system set up, and drying the left over in a muffle furnace. Ash content analysis was by weighted samples in porcelain crucibles burnt to ashes in a muffle furnace for six hours at 500°C. The residue was weighed and determined as ash content (Ash % = Final weight of crucible – Initial weight of crucible × 100). Moisture content determination was by the use of Annd Auto Analyser, (Model: ML50). The equipment was switched on to warm for one hour to set the drying temperature to 130 °C. The weighing pan on analyser was tare and approximately 1g of well blended sample placed on the pan. The equipment is startup which automatically measures the moisture content and displays it on the screen in percentage. Nitrogen free extract determination was estimated by calculation, by determining the amount of material left after de-

ducting the other contents. NFE % = 100 - (Crude Protein + Fat + Crude Fibre + Ash + Moisture). The metabolizable energy of samples were calculated according to (Pauzenga, 1985): ME (kcal/g) = (37 x Crude Protein) + (81.8 x Fat) + (35 x N.F.E). The gross energy of samples were determined by burning in a closed container (Bomb calorimeter) and heat produced from it were measured (AOAC, 2000).

Amino acid profile analysis

The amino acid analyses of samples (n = 5), were determined according to (Benitez, 1989). Weighed samples were dried to constant weight; fat extraction was done in soxhlet extraction apparatus using chloroform/methanol mixture of ratio 2:1 for fifteen hours. Fat extracted samples were weighed and hydrolysed with 7ml of 6NHCL expelling oxygen as nitrogen was introduced thus eliminating methionine and cysteine oxidation in hydrolysis process. The hydrolysed samples were sealed in glass ampoules and oven dried at 105 °C for 22 hours. The hydrolysate was dispensed into the cartridge of the analyser loaded into the Applied Biosystems PTH (phenylthiohydantoin Model 120A) amino acid analyser which calculates the peak area proportional to the concentration of each of the amino acids. During hydrolysis tryptophan an essential amino acid but was determined in sample by hydrolysing with 4.2M sodium hydroxide (Robel, 1984) and hydrolysate loaded in the analyser to determine tryptophan.

Mineral content analysis was conducted by wet ashing method, 0.5 g of the milled sample placed into a beaker with 10 ml mixture of nitric acid and perchloric acid added and placed on a heating mantle at 105 °C for 30 minutes and digested. The digest made up to 25ml with distilled water and sample read on Buck Scientific atomic absorption spectrophotometer (Model 210/211 VGP) to determine the concentration of the minerals at corresponding wavelengths and potassium read on a Jenway digital flame photometer (P7P model), while Phosphorus was determined by colorimetrically using Vanadomolybdate method and read on Spectrophotometer NIV 210.

Statistical analysis

The data were analysed using one-way analysis of variance (ANOVA), results from triplicate determination expressed as mean ± standard error (SE) and significant differences tested with Duncan Multiple Range test at P-value of 0.05 using SPSS version 20.0.

3. Results and discussion

Results

The proximate analysis of differently processed Cattle hoof (Table 1) showed significant difference (P<0.05) among all parameters analysed.

Table 1
Proximate analysis of differently processed Cattle Hoof

Proximate analysis	Soda ash hoof	Wood ash hoof	Fermented hoof	Autoclaved hoof	Raw hoof
Crude protein (%)	87.67 ± 0.20 ^b	86.53 ± 0.23 ^c	85.27 ± 0.20 ^d	90.20 ± 0.13 ^a	90.74 ± 0.26 ^a
Fat (%)	0.31 ± 0.01 ^c	0.54 ± 0.02 ^c	0.76 ± 0.02 ^b	0.40 ± 0.01 ^d	1.47 ± 0.02 ^a
Moisture content (%)	10.70 ± 0.12 ^c	9.30 ± 0.06 ^d	9.30 ± 0.12 ^d	11.14 ± 0.04 ^b	12.39 ± 0.01 ^a
Ash (%)	0.38 ± 0.01 ^d	0.34 ± 0.01 ^d	0.72 ± 0.01 ^c	0.99 ± 0.01 ^b	2.50 ± 0.12 ^a
Crude fibre (%)	12.71 ± 0.15 ^a	3.19 ± 0.06 ^c	7.95 ± 0.06 ^b	1.72 ± 0.14 ^d	0.19 ± 0.02 ^c
M.Energy (kcal/kg)	3269.15 ± 7.00 ^c	3238.38 ± 6.88 ^{cd}	3217.16 ± 5.59 ^d	3370.12 ± 5.86 ^b	3477.63 ± 11.50 ^a
G.Energy (kcal/kg)	5642.20 ± 0.00 ^a	5163.30 ± 0.00 ^d	5320.00 ± 0.00 ^c	5506.70 ± 0.00 ^b	5597.64 ± 0.00 ^a

Values (means ± SE) in a row with similar superscripts are not significantly different (P > 0.05)

The highest value of crude protein, fat, moisture content and ash was in raw hoof samples while crude fibre was high in soda ash treated sample.

Significant difference ($P < 0.05$) was observed in the Essential Amino Acid (EAA) Table 2 lysine, histidine and threonine for fermented hoof and methionine, arginine, isoleucine leucine (EAA); aspartic, serine, glutamic acid,

alanine, tyrosine and glycine Non-Essential Amino Acid (NEAA) of raw hoof; soda ash treatment significant difference ($P < 0.05$) of valine and proline while wood ash was significantly different ($P < 0.05$) for phenylalanine and cysteine in all treatments. Tryptophan was not detected in all samples analysed.

Table 2
Amino acid profile of differently processed Cattle Hoof meal (g/100g)

EAA	*AFRIS horn/hoof	Soda ash hoof	Wood ash hoof	Fermented hoof	Autoclaved hoof	Raw hoof
Lysine	4.8	4.61 ± 0.06 ^c	4.93 ± 0.04 ^b	5.04 ± 0.02 ^a	4.03 ± 0.00 ^d	4.61 ± 0.01 ^c
Histidine	1.2	1.15 ± 0.03 ^b	1.15 ± 0.00 ^b	1.28 ± 0.01 ^a	1.02 ± 0.01 ^c	1.15 ± 0.02 ^b
Arginine	9.8	9.98 ± 0.01 ^b	8.95 ± 0.02 ^d	9.81 ± 0.01 ^c	8.94 ± 0.00 ^d	10.49 ± 0.01 ^a
Threonine	4.8	5.00 ± 0.00 ^c	4.83 ± 0.02 ^d	5.63 ± 0.02 ^a	4.66 ± 0.02 ^c	5.38 ± 0.02 ^b
Valine	5.7	6.14 ± 0.02 ^a	6.02 ± 0.02 ^{ab}	5.49 ± 0.02 ^c	5.03 ± 0.02 ^d	5.90 ± 0.10 ^b
Methionine	2.2	2.19 ± 0.03 ^{ab}	2.03 ± 0.00 ^c	2.08 ± 0.03 ^c	2.14 ± 0.01 ^b	2.24 ± 0.01 ^a
Isoleucine	4.1	3.93 ± 0.02 ^c	3.67 ± 0.03 ^d	4.12 ± 0.00 ^a	3.99 ± 0.02 ^b	4.12 ± 0.01 ^a
Leucine	9.1	8.87 ± 0.01 ^a	8.40 ± 0.08 ^b	7.76 ± 0.01 ^c	7.47 ± 0.04 ^d	8.93 ± 0.01 ^a
Phenylalanine	3.4	3.19 ± 0.00 ^b	3.55 ± 0.01 ^a	3.19 ± 0.00 ^b	3.19 ± 0.00 ^b	3.19 ± 0.00 ^b
Tryptophan	ND	BDL	BDL	BDL	BDL	BDL
NEAA						
Aspartic acid	7.9	8.13 ± 0.02 ^c	8.31 ± 0.02 ^b	8.31 ± 0.06 ^b	7.81 ± 0.01 ^d	8.43 ± 0.01 ^a
Serine	7.0	6.86 ± 0.01 ^b	6.59 ± 0.02 ^c	6.21 ± 0.06 ^d	6.26 ± 0.09 ^d	7.34 ± 0.05 ^a
Glutamic acid	16.4	15.30 ± 0.02 ^b	14.53 ± 0.01 ^d	14.84 ± 0.01 ^c	13.02 ± 0.01 ^e	15.89 ± 0.03 ^a
Proline	6.1	6.60 ± 0.01 ^a	6.29 ± 0.02 ^c	6.39 ± 0.01 ^b	5.48 ± 0.02 ^d	6.39 ± 0.02 ^b
Alanine	5.1	4.63 ± 0.04 ^a	4.32 ± 0.02 ^b	4.70 ± 0.03 ^a	4.70 ± 0.02 ^a	4.70 ± 0.02 ^a
Cysteine	1.0	0.97 ± 0.01 ^b	1.09 ± 0.02 ^a	0.85 ± 0.01 ^c	0.85 ± 0.00 ^c	0.97 ± 0.01 ^b
Tyrosine	4.6	4.39 ± 0.02 ^b	4.21 ± 0.01 ^c	3.96 ± 0.01 ^d	3.78 ± 0.01 ^e	4.64 ± 0.00 ^a
Glycine	6.9	6.22 ± 0.13 ^b	5.84 ± 0.01 ^c	6.51 ± 0.01 ^a	5.37 ± 0.02 ^d	6.51 ± 0.01 ^a

EAA: essential amino acid; NEAA: Non-essential amino acid; ND: Not detected; BDL: Below detectable limit

Values (means ± SE) in a row with similar superscripts are not significantly different ($P > 0.05$)

Source: *AFRIS/Feedpedia 2017

In Table 3 both macro and micro mineral content of sample and processed treatments showed ranged variations. Autoclaved treatment was highest and significantly different ($P < 0.05$) in Ca, P, Na, Mn and Zn; Wood ash treatment had

highest values for K, Mg and Fe while the raw sample Cu content was highest which also showed significantly difference ($P < 0.05$) in processed sample.

Table 3
Mineral profile of differently processed Cattle Hoof

Mineral analysis	Soda ash hoof	Wood ash hoof	Fermented hoof	Autoclaved hoof	Raw hoof
Calcium (%)	5.30 ± 0.17 ^c	21.60 ± 0.23 ^b	16.20 ± 0.15 ^c	25.10 ± 0.27 ^a	13.00 ± 0.12 ^d
Phosphorus (%)	5.50 ± 0.31 ^d	7.40 ± 0.21 ^c	3.70 ± 0.21 ^e	14.60 ± 0.48 ^a	8.70 ± 0.06 ^b
Potassium (%)	0.60 ± 0.00 ^d	12.00 ± 0.12 ^a	0.70 ± 0.00 ^d	4.60 ± 0.15 ^c	7.80 ± 0.23 ^b
Sodium (%)	3.70 ± 0.10 ^b	2.10 ± 0.10 ^c	1.70 ± 0.06 ^d	9.00 ± 0.21 ^a	1.50 ± 0.00 ^d
Magnesium (%)	2.80 ± 0.10 ^d	12.10 ± 0.15 ^a	9.20 ± 0.12 ^b	3.20 ± 0.00 ^c	3.50 ± 0.00 ^e
Manganese (mg/kg)	3.00 ± 0.00 ^d	7.50 ± 0.32 ^b	5.00 ± 0.10 ^c	24.0 ± 0.10 ^a	1.00 ± 0.00 ^e
Zinc (mg/kg)	0.77 ± 0.01 ^c	0.68 ± 0.00 ^d	0.63 ± 0.00 ^e	0.91 ± 0.01 ^a	0.83 ± 0.01 ^b
Copper (mg/kg)	0.85 ± 0.00 ^b	0.80 ± 0.00 ^c	0.80 ± 0.00 ^c	0.88 ± 0.00 ^b	2.45 ± 0.32 ^a
Iron (mg/kg)	256.50 ± 0.72 ^c	307.50 ± 0.90 ^a	19.90 ± 0.12 ^e	286.00 ± 0.72 ^b	115.00 ± 0.58 ^d

Values (means ± SE) in a row with similar superscripts are not significantly different ($P > 0.05$)

Discussion

1. Proximate Composition

The processing methods used in this study compared to (Owen et al., 1953a; Falaye, 1982; Omitoyin, 1995; Coward-kelly et al., 2006; Sotolu, 2008). Feather meal (Adejumo et al., 2016) was also subjected to wood ash processing method. These were carried out in order to break the disulphide bond which makes keratin product protein unavailable for usage by livestock. The crude protein were higher than

that reported for mixture of horn and hoof meal 88.6 % (Gohl, 1981); feather meal 81.15 % (Falaye, 1982); 83.02 % (Omitoyin, 1995); and lower than that of (AFRIS, 2012) 93.3 % for Cattle horn and hoof and (Assis et al., 2017) 91.67 % for buffalo hoof but within the range reported for raw hoof 92.38 % by (Owen et al., 1953a). The fat content was lower than that reported by (Falaye, 1982) 6.7 %; (Omitoyin, 1995) 1.84 %; (AFRIS, 2012) 4.7 %; (Adejumo et al., 2016) 5.19 %; while ash in raw hoof was similar to

that of raw feather 2.34 % (Omitoyin, 1995) but lower to (Adejumo et al., 2016). The crude fibre in soda ash, wood ash and fermented hoof were higher than that reported by (Falaye, 1982; Omitoyin, 1995) 1.5; 2.3 respectively; while autoclaved and raw hoof were lower in comparison to the Scientists and (Adejumo et al., 2016) reported feather meal to contain no fibre which is not in line with this study. The different processing methods had effect on the nutritive constituents and this may be due to the action of catalytic enzyme (Kida et al., 1995) in the processes as raw hoof without processing showed significant difference ($P < 0.05$) among treatments except for its crude fibre content which was the lowest.

2. Amino Acid Composition

The EAA lysine for fermented hoof and methionine for raw hoof in all treatments, and the NEAA cysteine, proline and serine were similar to the observation of (AFRIS, 2012). Comparing the result of (Adejumo et al., 2016) it was observed that arginine, lysine, methionine, threonine in this study were higher in values than reported for feather meal 5.13 %; 2.89 %; 1.09 %; 4.02 %; cysteine, isoleucine in feather meal were higher in values than hoof meal while leucine and valine compared significantly with some treatment for this study. The amino acid compared favourably with (AFRIS, 2012) while tryptophan detected in feather meal in low amount 0.56 % (Adejumo et al., 2016) was below detectable limit in all sample of hoof and consistent to (AFRIS, 2012) that reported cattle horn/hoof with not tryptophan. Methods of processing and acidic process of amino acid determination has been reported to leads to loss of tryptophan and also affect the content of different samples (Wang & Parsons, 1997; Coward-Kelly et al., 2006). The variations observed in this study agreed with other Scientists that processing methods have effect on amino acid composition of keratin.

3. Mineral Composition

The methods used affected all the minerals analysed for, as the ash content in proximate composition was low which resulted in low mineralisation this supports the findings of (Owen et al., 1953a; 1953b) higher mineralization of hoof in soil due to heat treatment. There were however variations in the minerals of this study to that of (Gohl, 1981; AFRIS, 2012; Assis et al., 2017).

4. Conclusions

The methods employed in processing cattle hoof did not lower nutritional quality values from that reported in literatures. These methods can be used in production of quality protein from hoof keratin that can be utilized in livestock feedstuff as a means of feed cost reduction, environmental waste amelioration and provision of quality animal protein for livestock dietary needs.

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