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CHEMICAL COMPOSITION AND AMINO ACID PROFILE OF DIFFERENTLY PROCESSED FEATHER MEAL

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Abstract: Feather wastes represent potential alternative ingredients for animal feedstuffs which can ameliorate the protein shortage for food and feed. Previous attempts to provide information about the nutrient composition of feather meal are either too complicated for rural livestock farmers in developing countries or they provided incomplete information on chemical composition. Washed feathers were subjected to different processing techniques such as pre-soaking in distilled water, wood ash, 0.3M NaOH, a mixture of wood ash and 0.3M NaOH, incubated at 37^{o}C and boiled at 150^{o}C for 60 minutes. Treated feather meals were analysed for chemical composition and amino acid profile. The overall result showed that feather meal pre-soaked with wood ash for 24 hr boiled at 150^{o}C for 60 minutes, those pre-soaked with 0.3M NaOH and wood ash incubated at 37^{o}C for 24 hr boiled at 150^{o}C for 60 minutes and raw feather meal pre-soaked in distilled water for 24 hr boiled at 150^{o}C for 60 minutes gave better results. Wood ash and 0.3M NaOH and their mixture could enhance the nutritional value of feather meal.

Key words: ash, amino acids, boiling, chemical composition, feather meal.

Introduction

Globally, feathers are produced in large quantities annually as a by-product of poultry processing (Fakhfakh et al., 2010). Feathers could account for about 6% of the live weight of the mature chicken. They are rich in a keratinous protein, which is a fibrous and insoluble protein (Swetlana and Jain, 2010). Feathers have uses in erosion control, diaper filling, biodegradable composites, green house industry, animal feeds, upholstery, artwork, paper alternatives, light-weight structural materials, water filtration fibers, fabric, aircraft and automotive industries and

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thermal insulation (Comis, 1998; Schmidt, 1998). Feather protein is not easily degradable, thereby affecting its digestibility and use as livestock feed. Hence, it becomes necessary to develop effective, easy and cheap processing techniques that will hydrolyse feathers.

Feather meal is rich in protein which is under-utilised for animal nutrition, particularly in the developing countries. Its major limitation is that little information exists regarding its nutrient composition as well as the effective processing techniques that could enhance its nutritional values. Previous attempts to provide information about the nutrient composition of feather meal are either too complicated for rural livestock farmers in developing countries or they provided incomplete information on chemical composition and amino acid (NRC, 1994; Cotanch et al., 2007). Several researchers have investigated chemical or enzymatic methods for the hydrolysis of feathers (Steiner et al., 1983; Onifade, 1998; Moritz and Latshaw, 2001). Wood ash is used traditionally by gardeners as a good source of potash for domestic gardens and it is used to soften food stuffs such as locust bean seeds for making seasoning. It has been reported that potassium hydroxide can be made directly from wood ash (Anonymous, 2016), potassium hydroxide made in that form is known as a caustic potash or lye. NaOH and KOH are caustic chemicals which can be interchangeably used in a variety of situations. NaOH reacts with water to give lye solution. This present study aims at creating the nutrient profile of differently processed feather meal as a substitute for protein of animal origin, particularly for monogastric animals in developing countries.

Material and Methods

The protocol used in this study was reviewed and approved by Landmark University Animal Care and Use Committee, Nigeria. All the reagents used were of analytical grade.

Processing of feather meal

Fresh feathers from 8-wk white feather broilers (arbor acre) were obtained from Landmark University Commercial Farm. They were washed severally with distilled water. Washed feathers were subjected to different processing techniques: T1 contained 10 g of raw feathers pre-soaked in distilled water for 24 hr, boiled at 150^{o}C for 1 hr, then dried in a circulating air-drying oven at 50^{o}C for 24 hr; T2 contained 10 g of feathers pre-soaked with 0.3M NaOH for 24 hr boiled at 150^{o}C for 1 hr then dried in a circulating air-drying oven at 50^{o}C for 24 hr; T3 contained 10 g of feathers pre-soaked with ash from hard wood at 12 g/L for 24 hr, boiled at 150^{o}C for 1 hr then dried in a circulating air-drying oven at 50^{o}C for 24 hr; T4 had 10 g of feathers pre-soaked with 0.3M NaOH incubated at 37^{o}C for 24 hr, boiled at

150°C for 1 hr then dried in a circulating air-drying oven at 50°C for 24 hr; T5 contained 10 g of feathers pre-soaked with wood ash incubated at 37°C for 24 hr boiled at 150°C for 1 hr then dried in a circulating air-drying oven at 50°C for 24 hr; T6 contained 10 g of feathers pre-soaked with 0.3M NaOH and ash from hard wood at 12 g/L for 24 hr boiled at 150°C for 1 hr then dried in a circulating air-drying oven at 50°C for 24 hr; T7 contained 10 g of feather pre-soaked with 0.3M NaOH and ash from hard wood at 12 g/L incubated at 37°C for 24 hr boiled at 150°C for 1 hr then dried in a circulating air-drying oven at 50°C for 24 hr; T8 contained 10 g of feathers pre-soaked with 0.3M NaOH not boiled but dried in a circulating air-drying oven at 50°C for 24 hr; T9 contained 10 g of raw feathers not soaked, not boiled but dried in a circulating air-drying oven at 50°C for 24 hr. Each treatment was done in triplicates.

Chemical analyses

The proximate composition and amino acid profile of differently processed feather meal were carried out using DA 7250 NIR analyser (Pertem, Sweden).

Statistical analysis

The mean values obtained for the proximate composition and amino acid profile were subjected to an analysis of variance using PROC General Linear Model of SAS (Statistical Analysis System 9.3, SAS Institute, Cary, NC, USA). Significant means were separated using Duncan's multiple range test (Duncan, 1955). Each treatment (processing technique) served as the experimental unit. Results are presented as means plus standard deviation of $P<0.05$ defined as significant.

Results and Discussion

Proximate analysis

The proximate analysis of differently processed feather meal is presented in Table 1. The result of the proximate composition revealed that dry matter content was highest for those in T3 (86.92%) closely followed by those of T5 (86.90%), while those of T1 (86.68%), T2 (86.43%) and T4 (86.65%) were statistically similar to T3 and T5. T6 (84.04%) recorded the lowest value. Total protein content was significantly ($P<0.05$) highest for T3 (88.06%) closely followed by T1 (87.18%), while the lowest value was recorded for T8 (84.04%) followed by T9 (84.26%) and T6 (84.45%). T6, however, recorded significantly ($P<0.05$) highest fat content (5.83%) followed by T8 (5.61%) which was statistically similar to T6 and T7 (5.47%). The lowest value was recorded for T4 (4.59%) followed by T1

(4.89%) and T3 (4.89%). Ash content was significantly (P<0.05) highest for T2 (9.04%), followed by T8 (8.77%), whereas T7 recorded the lowest ash content (3.19%) followed by T3 (3.90%).

Table 1. Proximate composition of differently processed feather meal.

Treatments	Moisture	DM	Protein	Fat	Ash
T1	13.33±0.04^{de}	86.68±0.14^{ab}	87.15±0.14^{b}	4.89±0.01^{d}	6.45±0.06^{c}
T2	13.58±0.15^{d}	86.43±0.15^{ab}	85.97±0.10^{e}	4.94±0.16^{d}	9.04±1.27^{a}
T3	13.09±0.02^{e}	86.92±0.02^{a}	88.06±0.28^{a}	4.89±0.16^{d}	3.90±0.83^{d}
T4	13.35±0.08^{de}	86.26±0.08^{ab}	86.26±0.03^{de}	4.54±0.03^{e}	7.01±1.24^{bc}
T5	13.10±0.03^{e}	86.90±0.03^{a}	86.64±0.24^{cd}	5.22±0.04^{c}	4.05±0.71^{d}
T6	15.96±0.16^{a}	84.04±0.16^{e}	84.45±0.32^{f}	5.83±0.09^{a}	6.86±0.51^{c}
T7	15.38±0.24^{b}	84.62±0.24^{d}	86.80±0.18^{bc}	5.47±0.08^{bc}	3.19±0.71^{d}
T8	15.38±0.21^{b}	84.68±0.21^{d}	84.04±0.08^{f}	5.61±0.16^{ab}	8.77±0.28^{ab}
T9	14.64±0.10^{c}	85.36±0.10^{c}	84.26±0.32^{f}	5.30±0.15^{c}	6.51±0.55^{c}

DM = dry matter, T1 = raw feather meal pre-soaked in distilled water for 24 hr boiled at 150ºC for 1hr; T2 = feather meal pre-soaked with 0.3M NaOH for 24 hr boiled at 150ºC for 1 hr; T3 = feather meal pre-soaked with wood ash for 24 hr boiled at 150ºC for 1hr; T4 = feather meal pre-soaked with 0.3M NaOH incubated at 37ºC for 24 hr boiled at 150ºC for 1hr; T5 = feather meal pre-soaked with wood ash incubated at 37ºC for 24 hr boiled at 150ºC for 1 hr; T6 = feather meal pre-soaked with 0.3M NaOH and wood ash for 24 hr boiled at 150ºC for 1hr; T7 = feather meal pre-soaked with 0.3M NaOH and wood ash incubated at 37ºC for 24 hr boiled at 150ºC for 1 hr; T8 = feather meal pre-soaked with 0.3M NaOH; T9 = raw feather meal not soaked, not boiled. Means within the same column with different superscripts are significantly (P<0.05) different.

Amino acid profile

Table 2 shows the amino acid profile of differently processed feather meal. Arginine was not significantly different across the treatments. T7 recorded the highest cysteine content (6.29%), followed by T3 (5.79%), while T8 (3.97%) recorded the lowest value followed by T2 (4.24%). The highest isoleucine content was recorded in T7 (5.54%) followed by T3 (5.15%) which was statistically similar to the value obtained for T1 (5.05%), while T4 (4.32%) recorded the lowest value followed by T2 (4.34%) and T8 (4.36%). Leucine content was highest for T8 (8.33%) followed by T3 (7.89%) and T1 (7.85%), while the lowest values were recorded in T8 (6.95%) and T4 (6.96%). Lysine content was significantly (P<0.05) lower for T6 (2.47%) followed by T7 (2.48%) while T1 had the highest value (3.39%) closely followed by T9 (3.22%) and T8 (3.13%). Methionine content was significantly (P<0.05) higher for T5 (1.26%), T9 (1.16%), T3 (1.17%), T1 (1.15%) and T8 (1.14%). T7 (4.47%) recorded the highest value for threonine, closely followed by T1 (4.34%), while the lowest value was recorded in T4 (3.68%) followed by T8 (3.72%). T1 (0.65%) had the highest tryptophan closely followed

by T7 (0.60%) and T9 (0.60%). The lowest value was recorded in T6 (0.49%). T7 (7.46%) had the highest value of valine, followed by T3 (7.06%) and T1 (6.68%). The lowest value was obtained by T8 (5.72%) closely followed by T6 (5.96%). Lysine, methionine and tryptophan contents were lower across the treatments when compared with other amino acids studied.

Table 2. Amino acid profile of differently processed feather meal.

Parameters (%)	T1	T2	T3	T4	T5
Arginine	5.35±0.01	5.10±0.01	4.74±0.76	5.00±0.01	5.12±0.04
Cysteine	5.19±0.11^{c}	4.24±0.06^{ef}	5.79±0.08^{b}	4.42±0.02^{e}	5.25±0.11^{c}
Isoleucine	5.05±0.06^{bc}	4.34±0.01^{e}	5.15±0.03^{b}	4.32±0.06^{e}	4.85±0.07^{cd}
Leucine	7.85±0.08^{b}	7.00±0.06^{d}	7.89±0.06^{b}	6.90±0.08^{d}	7.55±0.15^{bc}
Lysine	3.39±0.08^{a}	2.66±0.01^{c}	2.96±0.04^{b}	2.61±0.04^{c}	3.06±0.06^{b}
Methionine	1.15±0.01^{a}	0.84±0.07^{c}	1.17±0.10^{a}	0.90±0.01^{bc}	1.26±0.02^{a}
Threonine	4.34±0.03^{ab}	3.77±0.03^{d}	4.31±0.02^{b}	3.68±0.04^{d}	4.14±0.11^{c}
Tryptophan	0.65±0.01^{a}	0.56±0.02^{bc}	0.55±0.05^{bc}	0.53±0.04^{bc}	0.54±0.01^{bc}
Valine	6.68±0.11^{c}	5.95±0.04^{de}	7.06±0.01^{b}	6.03±0.02^{de}	6.65±0.10^{c}

Table 2. Continued.

Parameters (%)	T6	T7	T8	T9
Arginine	4.71±0.07	5.24±0.17	5.00±0.10	4.99±0.01
Cysteine	4.54±0.06^{e}	6.29±0.37^{a}	3.97±0.04^{f}	4.86±0.07^{d}
Isoleucine	4.46±0.11^{e}	5.54±0.21^{a}	4.36±0.03^{e}	4.73±0.05^{d}
Leucine	7.12±0.40^{cd}	8.33±0.29^{a}	6.95±0.05^{d}	7.32±0.13^{cd}
Lysine	2.47±0.25^{c}	2.48±0.2^{c}	3.13±0.02^{ab}	3.22±0.03^{ab}
Methionine	1.05±0.08^{abc}	1.21±0.24^{a}	1.14±0.09^{ab}	1.16±0.07^{a}
Threonine	3.77±0.08^{d}	4.47±0.12^{a}	3.72±0.06^{d}	3.99±0.03^{c}
Tryptophan	0.49±0.01^{c}	0.60±0.07^{ab}	0.56±0.01^{bc}	0.60±0.04^{ab}
Valine	5.96±0.11^{de}	7.46±0.37^{a}	5.72±0.06^{e}	6.24±0.06^{d}

T1 = raw feather meal pre-soaked in distilled water for 24 hr boiled at 150^{o}C for 1 hr; T2 = feather meal pre-soaked with 0.3M NaOH for hr boiled at 150^{o}C for 1 hr; T3 = feather meal pre-soaked with wood ash for 24 hr boiled at 150^{o}C for 1hr; T4 = feather meal pre-soaked with 0.3M NaOH incubated at 37^{o}C for 24 hr boiled at 150^{o}C for 1 hr; T5 = feather meal pre-soaked with wood ash incubated at 37^{o}C for 24 hr boiled at 150^{o}C for 1 hr; T6 = feather meal pre-soaked with 0.3M NaOH and wood ash for 24 hr boiled at 150^{o}C for 1hr; T7 = feather meal pre-soaked with 0.3M NaOH and wood ash incubated at 37^{o}C for 24 hr boiled at 150^{o}C for 1 hr; T8 = feather meal pre-soaked with 0.3M NaOH; T9 = raw feather meal not soaked, not boiled. Means within the same column with different superscripts are significantly ($P<0.05$) different.

The proximate compositions of the feather meal showed that feather meal had higher dry matter content (84.04%–86.92%) and total protein (84.26%–88.06%). Cotanch et al. (2007) earlier reported a range of 90.40%–97.40% for dry matter, 84.10%–92.00% for crude protein content, 6.10%–14.80% for fat and 1.50%–3.60% for ash content for feather meal from various plants, while methionine, lysine, histidine and tryptophan were very low when compared with other amino acids. Wang and Parsons (1997) reported an average of 88.70% for crude protein while Morel et al. (2003) reported a range of 82.20%–84.60% for protein content. Ajayi and Iyayi (2014) earlier reported that feather meal contained 83.80%–89.90% crude protein, 0.30–0.60% ash and 5.00%–10.30% ether extract. The results of the present study revealed that lysine, methionine and tryptophan contents were lower across the treatments when compared with other amino acids studied. Moritz and Latshaw (2001) earlier observed a similar trend for methionine (0.50%–0.56%) and lysine (1.74%–1.91%). Previous findings also indicated that the first limiting amino acid in feather processing was methionine (Rutkowski, 1988; Rutkowski et al., 2003). It has earlier been reported that feather meal is a good source of leucine and cystein while lysine, methionine and tryptophan are limiting. Isika et al. (2006) also observed high crude protein content for feather meal. Lysine (0.46%), methionine (0.35%) and tryptophan (0.56%) were limiting when compared with other amino acid profiles studied by the authors.

When feeding feather meal processed in the above stated ways to monogastric animals, there may be a need to supplement the diet with lysine and methionine in order to boost the limiting amino acids in the diets. It has earlier been reported that feather meal contains a high proportion of sulphur amino acids with 6:1 of cystine to methionine (Cotanch et al., 2007; Liu et al., 1989; Han and Parson, 1991). Amino acids (AAs) were traditionally classified as nutritionally essential or non-essential for animals and humans based on nitrogen balance or growth. All non-essential AAs (NEAAs) were assumed to be synthesized adequately in the body as substrates to meet the needs for protein synthesis. Animal diets need the adequate amount of all essential AAs in order to optimize animal performance. If the dietary concentration of one particular amino acid is too low, others may not be used efficiently. Nutrient content of a feed determines the voluntary intake of animals, which in turn affects the growth rate, productivity and efficiency. Feed intake is depressed by a deficiency in the limiting amino acid or an excessive supply of some essential AAs [21]. The need for maintenance and the need for protein accretion determine AA requirements by animals (Fuller et al., 1989). The AA in practice is expressed relative to lysine (Millet, 2012). Tryptophan supplement to a tryptophan-limiting diet has been shown to boost feed intake in piglets (Jansman et al., 2010), while low levels of valine were reported to result in lower feed intake (Mavromichalis et al., 2001; Theil et al., 2004). Low valine diets result in lower feed intake and daily gain (Millet, 2012; Lordelo et al., 2008; Wiltafsk et al., 2010).

Somatostatin has been indicated as a factor responsible for anorexia induced by valine-deficient diets (Nakahara et al., 2011). Tryptophan has been shown to compete with large neutral amino acids (LNAAs) such as leucine, isoleucine and valine for its passage through the blood-brain barrier by sharing a common transport system (Fernstrom and Wurtman, 1972). Decreased feed intake has been attributed to a low tryptophan diet which consequently affects serotonin concentration in the brain (Henry, 1992). Millet (2012), however, has observed that supplementing valine or tryptophan to a diet limiting in both AAs improves performance of pigs.

Conclusion

Feather meal pre-soaked with wood ash for 24 hr boiled at 150^{o}C for 1hr gave the best crude protein content, followed by those pre-soaked with 0.3M NaOH and wood ash incubated at 37^{o}C for 24 hr boiled at 150^{o}C for 1hr and raw feather meal pre-soaked in distilled water for 24 hr boiled at 150^{o}C for 1hr. In terms of amino acid profile, those pre-soaked with 0.3M NaOH and wood ash incubated at 37^{o}C for 24 hr boiled at 150^{o}C for 1hr gave the best result, comparably followed by those pre-soaked with wood ash for 24 hr boiled at 150^{o}C for 1hr and raw feather meal pre-soaked in distilled water for 24 hr boiled at 150^{o}C for 1hr. There seems to be beneficial effects of the use of wood ash and a mixture of wood ash and NaOH in the production of feather meal. However, further studies are recommended to assess the effect of the processing methods on animals' performance and digestibility.

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HEMIJSKI SASTAV I AMINOKISELINSKI PROFIL RAZLIČITO OBRAĐENOG BRAŠNA OD PERJA

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R e z i m e

Otpad od perja predstavlja potencijalno alternativan sastojak hrane za životinje koji može pomoći u razrešavanju problema nedostatka proteina u hrani. Prethodni pokušaji da se pruže informacije o nutritivnom sastavu brašna od perja su ili previše komplikovani za stočare u zemljama u razvoju ili su pružali nepotpune podatke o hemijskom sastavu. Isprano perje je bilo podvrgnuto različitim tehnikama obrade kao što su prednatapanje u destilovanoj vodi, pepelu od drveta, 0,3M NaOH, mešavini pepela od drveta i 0,3M NaOH, inkubirano na 37^{o}C i kuvano na 150^{o}C tokom 60 minuta. Tretirano brašno od perja je analizirano radi utvrđivanja hemijskog i aminokiselinskog sastava. Ukupan rezultat je pokazao da se najbolje pokazalo brašno od perja, koje je prethodno natapano pepelom od drveta tokom 24h kuvano na 150^{o}C tokom 60 minuta, i ono koje je prethodno natapano u 0,3M NaOH i pepelu od drveta inkubirano na 37^{o}C tokom 24 h i kuvano na 150^{o}C tokom 60 minuta i sveže brašno od perja prethodno natapano u destilovanoj vodi tokom 24 h kuvano na 150^{o}C tokom 60 minuta. Pepeo od drveta i 0,3M NaOH i njihova mešavina bi mogli poboljšati hranljivu vrednost brašna od perja.

Ključne reči: pepeo, aminokiseline, kuvanje, hemijski sastav, brašno od perja.

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