

Variability of dietary energy of shea nut (*Vitellaria paradoxa*) meal for poultry

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Shea nut meal is obtained after fat extraction from shea nuts in West Africa. The objective was to determine the effect of three dietary levels of different shea nut meals on metabolisable energy. Six shea nut meal samples produced in 2004 and 2005 [i.e. 4 industrial (expeller), 2 non-industrial (water-based extraction)] as well as two defatted samples (one of each type of shea nut meal) were fed at 3 dietary levels (0, 20, 40 g/kg) to 180 Ross 308 male broiler chicks (12-20 d). All droppings (last 4 days) were collected, dried and their gross energy (adiabatic bomb calorimeter) determined. ANOVA of data and orthogonal contrasts (GENSTAT) were used to compare the treatment means. Dietary level had significant ($P < 0.01$) non-linear effect on apparent metabolisable energy (AME) with the 40 g/kg level giving a lower AME. However, this effect was not evident ($P > 0.05$) for the two defatted samples. There was an interaction ($P < 0.05$) between the shea nut meals and dietary level. There were no significant ($P > 0.05$) differences between the industrial and non-industrial samples, and samples containing fat and defatted samples in determined AME. Removal of fat from the meal tended ($P > 0.05$) to improve AME.

Keywords: shea nut meal; metabolisable energy; broiler chicken

Introduction

Shea nut meal is obtained after fat extraction from nuts of the shea tree (*Vitellaria paradoxa*, Gaertn.) that grows in West Africa. Increasing world demand for shea fat for cosmetics and as a substitute for cocoa fat in chocolate (Hall *et al.*, 1996) has increased interest in the use of shea nut meal in poultry diets in Sub-Saharan Africa. Two common methods of fat extraction of the nuts are used. The industrialised screw-press process produces expeller meal and a local, non-industrial fat extraction method uses a water-based extraction procedure. There are relatively large supplies of both types of shea nut meal available to the feed industry with varying residual fat content. The fat is saturated with low metabolisable energy content (Dei *et al.*, 2006). The objective of this study was to determine the effect of three dietary inclusion levels (0, 20, 40 g/kg) of six original samples of shea nut meal (four expeller meals from two different factories and two growing seasons and two local, non-industrial meals from different seasons) and two defatted samples on dietary energy.

Materials and methods

Four shea nut meal samples were obtained from Shebu-Loders Croklaan Ltd, Savelugu (3 samples) and Juaben Oilmills, Juaben (1 sample) in Ghana. They were produced by the same industrial process (i.e. wet heating of the kernels prior to fat extraction using a screw-press/expeller machine). Two further shea nut meal samples were obtained from a local, non-industrial processor (Christian Mothers Association, Tamale). This material was produced by roasting of the kernels, grinding in a mill prior to water-based fat extraction using the hand to knead, scooping off fat emulsion and the collection of the residue for sun-drying. Three of these samples were produced during the 2004 growing season and

the other three in 2005. All the samples obtained were stored at ambient temperatures at source (approximately 25°C) and, after transport, in ambient UK temperatures. Two additional shea nut meal samples were prepared by removing the residual fat from two of the samples collected (i.e. 1 expeller and 1 non-industrial of the 2004 season). The fat in the shea nut meal was removed through continuous extraction with light petroleum spirit (b.p. 40-60°C) using a Soxtec system (Foss Ltd, UK).

Ross 308 male broiler chicks were reared in a litter-floored pen and fed a proprietary broiler starter feed for 12 days. At 12 days of age, 180 broilers of similar body weight were individually caged (0.3m x 0.3m x 0.36m) and fed one of 17 mash experimental diets to 20 d of age. Each shea nut meal sample was substituted at levels of 20 and 40 g/kg in a basal diet. The basal diet (g/kg) consisted of maize (400), dehulled soybean meal (300), fishmeal (30), wheatfeed (220), lysine (3), methionine (4), limestone (4), dicalcium phosphate (13), vitamin-trace mineral premix (22) and salt (4). The calculated composition of basal diet (g/kg) was crude protein (239.4), crude fibre (36.9), Ca (11.4), P (7.6), lysine (15.2), methionine (7.6) and metabolisable energy (11.5 MJ/kg). During the last 4 days of the 8-day experiment, the feed offered was restricted to an amount estimated to be 70% of *ad libitum* intake. This was done to avoid any confounding of lower feed intakes due to the presence of shea nut meal. The droppings were collected daily and stored at 4°C until the combined four-day sample was dried in a force-draught oven at 60°C.

The nutrient compositions of shea nut meal samples were determined using standard methods (AOAC, 2000), while total NSP were determined according to procedures outlined in the Megazyme assay kit (Megazyme International Ireland Ltd). Total extractable tannins were determined by the method of Martin and Martin (1982). Gross energy contents of feed and droppings were determined by adiabatic bomb calorimeter (Model 1261) and the dietary apparent metabolisable energy calculated.

Samples of shea nut meal and rate of inclusion were considered as treatment factors with tier level of cages as a blocking factor. ANOVA of data and orthogonal contrasts were used to compare the treatment means (GENSTAT, 8th version). The relationship between the determined AME of the samples and their chemical composition was examined by linear regression with groups (industrial or non-industrial meals) techniques.

Results and discussion

There were variations in the chemical composition of the two methods of processing shea nut meal, particularly in fat content, proportion of free fatty acids and tannins (*Table 1*). Further removal of the residual fat in the meal changed its chemical composition. All samples had very high proportions of NSP. There were no differences ($P>0.05$) in AME due to source of shea nut meal, but dietary levels had an effect ($P<0.01$) on AME (*Table 2*) with an interaction ($P<0.05$) between the diets and dietary levels. The dietary level of the six original, as-received shea nut meal samples had a significant ($P<0.01$) non-linear effect on AME with the 40 g/kg level giving a lower AME than the 20 g/kg level (*Table 2*). However, this effect was not evident ($P>0.05$) for the two defatted samples. Increasing dietary inclusion levels of these two samples tended ($P>0.05$) to improve AME of the diets (*Figure 1*). Comparisons between the industrially-derived and non-industrial meals, and as-received and defatted meals showed no significant ($P>0.05$) differences in dietary AME.

Table 1: Chemical composition (g/kg) and energy concentrations of shea nut meal samples (dry matter basis)

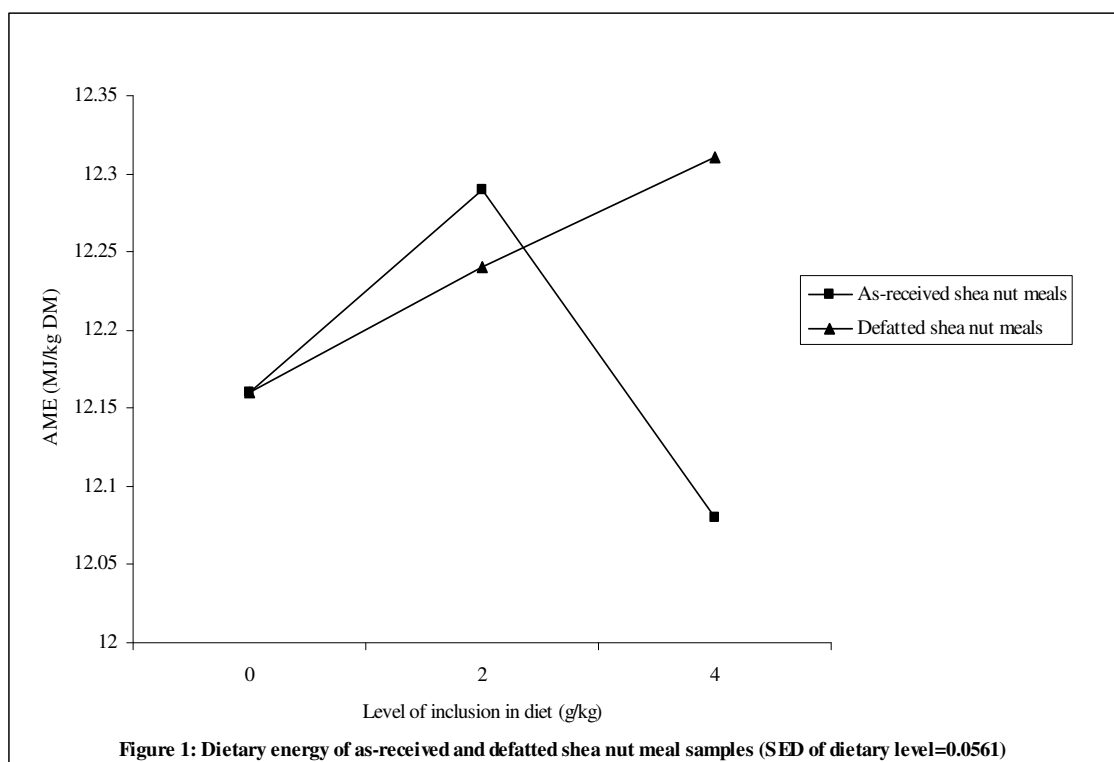
Component	Industrial (expeller) samples					Non-industrial samples		
	2004s batch 1	2004s batch 1 defatted	2004s batch 2	2005s	2005j	2004	2004 defatted	2005
Crude Protein	143.6	170.7	133.3	132.4	128.8	117.7	203.2	103.9
Ether Extracts (EE)	101.4	3.8	128.3	120.2	151.6	363.8	7.5	394.8
Free fatty acids (of EE)	160.0	nd	123.0	84.0	66.0	491.0	nd	237.0
Free fatty acids	16.2	nd	15.8	10.1	10.0	178.6	nd	93.6
Ash	52.3	64.5	50.6	54.2	46.9	75.6	128.9	51.6
Total NSP	376.0	416.8	381.7	396.6	380.5	305.9	477.2	316.9
Total tannins	147.6	295.5	119.2	177.7	201.3	35.1	nd	66.1
Gross Energy (MJ/kg)	22.8	18.9	24.0	23.8	24.3	26.0	18.7	27.4

s-Shebu-Loders Crocklaan Ltd j-Juaben Oilmills Ltd NSP-non-starch polysaccharide nd-not determined

Table 2: Apparent metabolisable energy of experimental diets

		AME (MJ/kg DM)			
Amount of sample in diet (g/kg)		0	20	40	Mean
Basal diet		12.16			
	Sample no.	Sample			
Industrial (expeller) shea nut meal	1	2004s ₁	12.35 ^A	12.02 ^B	12.18
	2	2004s ₂	12.29 ^A	12.18 ^B	12.23
	3	2005s	12.26 ^A	12.18 ^B	12.22
	4	2005j	12.26 ^A	12.18 ^B	12.22
		Mean	12.29	12.14	
Non-industrial shea nut meal	5	2004	12.31 ^A	12.01 ^B	12.16
	6	2005	12.28 ^A	11.90 ^B	12.09
		Mean	12.30	11.96	
Defatted industrial shea nut meal	7	2004s ₁	12.28 ^B	12.35 ^A	12.31
Defatted non-industrial shea nut meal	8	2004	12.19 ^B	12.26 ^A	12.22
Factor	SED (r.d.f.=96)		Probability		
Shea nut meal samples (S)	0.0959		P>0.05		
Level of inclusion in diet (L)	0.0479		P<0.01		
S x L	0.1356		P<0.05		

s-Shebu-Loders Croklaan Ltd (1-batch one, 2- batch two) j-Juaben Oilmills Ltd r.d.f.-residual degrees of freedom
^{A,B}Means with different superscripts in a column are significantly different (P<0.01)



The marked differences in tannin concentrations between the expeller and non-industrial shea nut meal samples (Table 1) may have been as a result of the water-based processing of the non-industrial meal. High moisture content conditions increases the complexing of tannins with proteins, and possibly other organic compounds, so that the tannin can no longer be extracted and assayed (Butler and Rogler, 1992). However, such complexed tannins may remain bio-active in poultry feeds and could still cause negative effects on nutrient utilisation (Mahmood *et al.*, 2006). The variability in the fat contents (Table 1) could be attributed to the different efficiencies of fat extraction methods within the industry (Womeni *et al.*, 2002); that is higher for the screw-press process. Also, the operational efficiency of the expeller process could influence the level of residual fat in the meal. The variation in the FFA content of the fat could either be due to a seasonal effect on kernels, harvesting and nut preparation methods (Hall *et al.*, 1996) or poor storage conditions at source that might cause oxidation.

The dietary concentration of fat (Wiseman *et al.*, 1986) can have marked effects on the metabolisable energy content of the feed. Even though the AME of refined shea fat is approximately 22MJ/kg (Dei *et al.*, 2006), there was no relationship ($P>0.05$) between the level of residual fat in the shea meal and the determined AME of the sample. The relatively low AME of shea fat, in comparison to other edible fats, is probably due to its very low unsaturated/saturated fatty acids ratio (1:1). However, the lack of relationship between total fat level and AME suggests that another quality factor may also have been important. All the samples had residual fats with relatively high FFA contents and, in particular, the non-industrial samples (*Table 1*). This implies that, due to its quality, the residual fat in the shea nut meal may not contribute significantly to its metabolisable energy content as expected (*Figure 1*). This fat and its composition have been implicated in lowering of true metabolisable energy of shea nut meal (12.6-15.1 MJ/kg DM) (Dei *et al.*, 2007). Thus processing methods that substantially improve fat extraction efficiency (e.g. solvent extraction process) from the shea kernels may enhance the quality of this by-product for feeding poultry. Also, the high NSP in shea nut meal have been implicated in its poor metabolisability (Morgan and Trinder, 1980), which may have also contributed to the low observed AME (*Table 2*).

In conclusion, the residual fat in shea nut meal accounted largely for variability in available energy concentrations, and its removal appeared to improve its AME at a high dietary level. Thus the residual fat and its FFA content are important quality variables of shea nut meal that affects its metabolisable energy. Therefore processing method that reduces the residual fat in the meal could improve its quality.

References

- ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, AOAC** (2000). Official methods of analysis. Association of Official Analytical Chemists, Washington, D.C.
- BUTLER, L.G. and ROGLER, J.C.** (1992). Biochemical mechanisms of the anti-nutritional effects of tannins. *American Chemical Society Symposium Series* **506**: 298-304.
- DEI, H.K., ROSE, S.P. and MACKENZIE, A.M.** (2006). Apparent metabolisable energy and digestibility of shea (*Vitellaria paradoxa*) fat, cocoa (*Theobroma cacao*) fat and soybean oil in broiler chicks. *British Poultry Science* **47**: 607-612.
- DEI, H.K., ROSE, S.P. and MACKENZIE, A.M.** (2007). Metabolisable energy of shea nut (*Vitellaria paradoxa*) meal for poultry. *British Poultry Abstracts* **3**: 36-37.
- HALL, J.B., AEBISCHER, D.P., TOMLINSON, H.F., OSEI-AMANING, E. and HINDLE, J.R.** (1996). *Vitellaria paradoxa*: a monograph. School of Agricultural and Forest Sciences Publication No. 8, 105 pp, University of Wales, Bangor.
- MAHMOOD, S., KHAN, M.A., SARWAR, M. and NISA, M.** (2006). Chemical treatments to reduce antinutritional factors in salseed (*Shorea robusta*) meal: Effect of nutrient digestibility in colostomized hens and intact broilers. *Poultry Science* **85**: 2207-2215.
- MARTIN, J.S. and M.M. MARTIN** (1982). Tannin assays in ecological studies: Lack of correlation between phenolics, proanthocyanidins and protein precipitating constituents in mature foliage of six Oak species. *Oecologia* **54**:205-211.
- MORGAN, B. and TRINDER, H.** (1980). The composition and nutritional value of some tropical and sub-tropical by-products. *British Society of Animal Production Occasional Paper* **3**: 91-111.
- WISEMAN, J., COLE, D.J.A., PERRY, F.G., VERNON, B.G. and COOKE, B.C.** (1986). Apparent metabolisable energy values of fats for broiler chicks. *British Poultry Science* **27**: 561-576.
- WOMENI, H.M., KAMGA, R., TCHIEGANG, C. and KAPSEU, C.** (2002). Extraction du beurre de karaté: influence du séchage des amandes et de la technique d'extraction. *Rivista Italiana delle Sostanze Grasse* **79**: 33-37.