

Full Length Research Paper

Proximate analysis of shea nut kernel cake/meal samples from industry and cottage industry and some methods of removal of anti-nutritional factors

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Shea nut kernel cake (SNC), a major by-product of the shea industry, is rich in carbohydrates and protein, but the presence of anti-nutritional factors, mainly theobromine and tannins, limits its use as animal feed material. The present work studied variations in the chemical composition of SNC from different shea nut processing industries in Ghana. Additionally, the work evaluated the effectiveness of physical treatments (T1 - water-soaked overnight, strained and dried; T2 - washed with flowing water and dried; T3 - water-soaked, kneaded, squeezed in jute bag and then dried; T4 - boiled and dried) and chemical treatments (T5 - wetted with NaOH solution and dried; T6 – wetted with NaCl solution and then dried) for eliminating or reducing total tannins and theobromine in SNC. Compositional analysis showed that SNC was high in protein (116 to 178 g/kg dry matter (DM) and crude fat (25 to 545 g/kg DM). The increasing order for the effectiveness of the treatments in reducing the tannin content of SNC was as follows: T0<T6<T2=T3<T1< T4=T5. The T5 was found to be the most effective treatment in significantly reducing total tannins and theobromine content of SNC (by 69.9 and 25% respectively) thus improving its nutritional value as a livestock feedstuff.

Key words: Shea nut kernel cake, chemical composition, theobromine, tannins, physical and chemical pre-treatments.

INTRODUCTION

Shea butter, a fat extracted from the fruit of the shea tree (*Vitellaria paradoxa*, Gaertner) is currently in high demand for use in cosmetics and also as a cocoa butter substitute in chocolate making. After fat extraction, a by-product, known as shea nut kernel cake/meal (SNC) is obtained. This material has been shown to vary in composition depending on whether extraction of fat was by an industrial (expeller and sometimes solvent) or traditional cottage industry method, with the industrial methods tending to be more efficient at fat extraction (Dei et al., 2007). The following range of nutrient compositions (g kg⁻¹ DM): crude protein (80 to 250), ether extract (17-362), crude fibre (53 to 138), ash (33 to 76)

and nitrogen-free extract (318 to 675) have been reported (Dei et al. 2007). They also reported that the major part of this variability could be traced to the amount of fat extracted, handling of the nuts prior to processing and seasonal effects on nut production. Dei et al. (2007) also reported an estimated true metabolisable energy corrected for nitrogen balance (TMEn) to be 12.6 MJ kg⁻¹ to 15.1 MJ kg⁻¹ for different SNC samples.

SNC has been found to contain some anti-nutritive factors and the following have been reported: saponins (Gohl, 1981), tannins (Okai, 1990), theobromine (Rhule, 1999), saponins and theobromine (Atuahene et al., 1998) and saponins and tannins (Annongu et al., 1996). The variations obtained may be due to the different analytical methods used as well as the sensitivity of the methods in detecting the anti-nutritional factors.

Based on its composition, SNC should find some use in animal feeding. The level of anti-nutritional factors has,

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however, limited its use. Published works suggest the following maximum inclusion levels: for poultry; Atuahene et al. (1998), Adeogun (1989), Osei-Amaning (1993) and Oloredo and Longe (1999), reported 25, 50 and 100 g kg⁻¹, respectively, while for pigs, Okai (1990) and Rhule (1995), reported 50 and 100 g kg⁻¹, respectively. Some forms of intervention to minimize the effects of these anti-nutritional factors to allow increased use of SNC in poultry and livestock diets is therefore indicated. Thus, the aim of the study was to analyze SNC from various industrial and cottage industry sources and also to evaluate some known methods of dealing with anti-nutritional factors.

MATERIALS AND METHODS

Survey

SNC samples were obtained from three (3) shea nut processing cottage industries in Bole, a town in the Northern region of Ghana, and labeled as Bole A, B, and C. SNC samples were also obtained from two (2) industrial sources, namely Shebu Industries in Tamale in the Northern region of Ghana and the Ghana Nuts factory in Techiman, in the Brong Ahafo region of Ghana. These samples were subjected to proximate chemical analysis (AOAC, 2000), detergent fibre and detergent lignin analysis (van Soest et al., 1991). Tannin was extracted with ethyl acetate using soxhlet apparatus for about 3 hours. The solvent was distilled off and the residue repeatedly washed with petroleum ether (40 to 60°C) until no more colour was extracted. The residue was then dissolved in 10 ml ethyl acetate. To 5 ml of the tannin extract were added 5 ml of Folin Ciocalteu reagent and 10 ml of saturated sodium carbonate solution. This was diluted to 5 ml with distilled water and left standing for an hour. The absorbance of the resulting blue complex was read at 725 nm against a blank. The same treatment was given to the tannic acid standard and the concentration of tannin in the sample estimated from a standard curve (Akaninwor and Okechukwu, 2004),

Methods of tannin and theobromine removal

A sample (25 kg) was obtained from the Ghana Nuts factory, thoroughly mixed and divided into 25 lots of one (1) kilogram each. The one (1) kilogram samples were randomly allocated to one of the following treatments:

T0. Untreated (control)

T1. Soak in water overnight, followed by straining and drying of the residue.

T2. Run a flow of water through the material for an hour after which the residue was dried.

T3. Soak the material, in a small jute bag (30 × 15 cm),

in a water bath for an hour followed by kneading and squeezing of the jute bag in the water bath for about ten minutes and drying of the residue.

T4. Boil/heat (75°C) for an hour, followed by straining and drying of residue.

T5. Apply 0.01M solution of sodium hydroxide (NaOH) to the material until thoroughly wet and allow material to dry.

T6. Apply 3% solution of sodium chloride (NaCl) to material until thoroughly wet and allow material to dry.

Each treatment was replicated three times. Samples from each treatment and replicate were assayed for their content of tannins (Akaninwor and Okechukwu, 2004), as an indication of the level of anti-nutritional factors.

Statistical analysis

The trial was set up as a completely randomized design, with the method of removal of anti-nutritional factors serving as the treatment. Tannin concentration in each sample was subjected to analysis of variance (ANOVA) using GENSTAT Release 9 (2007) software. Significantly different means ($P < 0.05$) were separated using the Least Significant Difference (LSD) method.

Comparison between NaOH treated SNC and untreated SNC

Sodium hydroxide (NaOH) treatment offered the most practical and cost-effective way of treating SNC. As such, another one (1) kg sample of SNC was treated with 0.01 M NaOH and compared with an untreated sample for proximate composition and levels of calcium and phosphorus (AOAC, 2000) content of anti-nutritional factors (theobromine (AOAC, 2000) and tannins (Akaninwor and Okechukwu, 2004) and pH, to determine the effects of NaOH treatment on these parameters.

RESULTS

Survey

The proximate composition and tannin levels of the various samples of SNC are shown in Table 1. Ether extract ranged from 25 g kg⁻¹ DM in the Ghana Nuts sample to 545 g kg⁻¹ DM in Bole C. It is interesting to note that even among the samples taken from Bole (cottage industry), ether extract content was quite variable and ranged from 390 g kg⁻¹ DM in Bole B to 545 g kg⁻¹ DM in Bole C. Fat extraction as indicated by ether extract content (residual fat in the samples) was best in the industrial samples. The amount of fat extracted affected the proportions of other constituents which varied accordingly. For example, crude fibre content

Table 1. Proximate analysis and tannin content of shea nut kernel cake/meal from different sources.

Parameter (g/Kg)	Bole A	Bole B	Bole C	Shebu Industries, Tamale	Ghana Nuts, Techiman
DRY MATTER	900	885	940	905	925
Organic matter	945	955	960	980	945
Ether extract	425	390	545	330	25
Crude fibre	53.8	59.3	45.5	93.8	114
Crude protein	116	133	117	159	178
¹ NDF	250	290	320	570	340
² ADF	180	220	250	450	450
³ ADL	172.8	211.7	240	445.9	710
Tannin	0.319	0.244	0.206	0.447	0.356

¹NDF = Neutral Detergent Fibre; ²ADF = Acid Detergent Fibre; ³ADL = Acid Detergent Lignin.

Table 2. Tannin levels in shea nut cake samples subjected to the various treatments.

T0	T1	T2	T3	T4	T5	T6	SED
22.220 ^a	13.778 ^b	17.465 ^c	17.205 ^c	6.157 ^d	6.678 ^d	19.242 ^e	0.3658

^{a-e}Means in the same row with different superscripts are significantly ($P < 0.001$) different, SED – Standard error of the difference between two means.

ranged from 114 g kg⁻¹ DM in the Ghana nuts sample to 45.5 g kg⁻¹ DM in the Bole C sample.

Methods of tannin and theobromine removal

Analysis of variance revealed significant differences ($P < 0.05$) between treatments with respect to their ability to reduce the tannin content in SNC as shown in Table 2. The results of the analysis categorize the treatments into groups with decreasing content of tannins as follows: T0 < T6 < T2=T3 < T1 < T4=T5

Comparison between NaOH treated SNC and untreated SNC

Table 3 shows the comparison of chemical composition and pH of the untreated shea nut kernel cake/meal and the NaOH-treated cake/meal. Although not statistically tested, the reduction in tannin content with NaOH treatment is confirmed (22.22 vs 6.68). There is also a reduction in theobromine content (7.20 vs 5.40). NaOH treatment did not appear to affect pH (5.48 vs 5.46) or crude protein content (178 vs 175) very much.

DISCUSSION

There was quite a large variation between samples of

SNC, even among three (3) samples taken from three (3) different processors in the Bole Township. Even though the processors use basically the same methods of extraction (water-based) the methods have not been standardized and could lead to such variation. Variations in the proximate composition of the SNC samples are due to the differences in the efficiency of shea butter extraction methods employed by the different industries. This is supported by the differences in residual fat estimated as ether extract values as shown in Table 1. Since the shea nuts are coming from different sources, variations will exist in the cultivation practices and other agronomic factors, which may have partly influenced the composition of the shea nut and subsequently the SNC samples generated after the butter extraction.

Tannins inhibit the activities of some enzymes like trypsin, amylase and lipase by forming insoluble complexes with protein (Griffiths, 1979) and divalent ions such as Fe²⁺ and Zn²⁺ thereby reducing their absorption in the body (Elegbede, 1998). Generally, it appears that the water-based extraction produces a material with a lower level of tannin (Table 2). This may suggest that shea nut cake contains a large proportion of tannins highly soluble in water, due to their free hydroxyl groups involved in strong hydrogen bond interaction with water molecules. The material from the Ghana Nuts factory was double pressed and then solvent extracted. This might have led to the low level of tannin and also a low value for ether extract.

Among the water based treatments, it was observed

Table 3. Proximate chemical composition, pH and theobromine and tannin contents of NaOH-treated and untreated shea nut kernel cake/meal.

Parameter (g/Kg)	Untreated	NaOH-treated
Dry matter	925	970
Organic matter*	945	915
Crude protein*	178	175
Ether extract*	25	50
Crude fibre*	114	124
² ADF*	340	380
¹ NDF*	450	520
³ ADL*	710	744
Calcium*	29	30
Phosphorus*	1.3	1.9
pH	5.48	5.46
Theobromine* (mg/Kg)	7.20	5.40
Tannin*	22.22	6.68

*Parameter was determined on dry matter (DM) basis; ¹NDF = Neutral Detergent Fibre; ²ADF = Acid Detergent Fibre; ³ADL = Acid Detergent Lignin.

that increase in treatment time (T1) or temperature (T4) resulted in a significant ($P < 0.05$) decrease in total tannins in SNC, suggesting that the solubility of tannins is enhanced by length of time and temperature (Salim-Ur-Rehman et al., 2002). This is in agreement with the findings of Oladele et al. (2009) who reported a decrease in tannin content of tiger nut with increase in soaking time. This could be attributed to the solubility of tannin in water which aids its leaching into soaking water. A similar result was also reported for pigeon pea (*Cajanus cajan*) and vegetable cowpea (*Vigna unguiculata*) when soaked in water (Onwuka, 2006).

The NaOH treatment (T5) of the SNC resulted in 69.9 and 25% decreases ($P < 0.05$) in the amounts of total tannins and theobromine level, respectively (Tables 2 and 3). The observed reduction in tannin levels may be due to alkaline hydrolysis and solubilisation of tannins, as these polyhydroxylated compounds are thought to undergo alkali-induced deprotonation and delocalisation of their pi electrons, rendering the carbon-carbon bonds linking their monomers susceptible to attack and cleavage by alkali (Kratzer and Singleton, 1969). The reduction in tannin may suggest a corresponding improvement in protein digestibility of SNC.

Chemical procedures for eliminating anti-nutrients, including theobromine, are usually expensive due to high cost of chemicals and sophisticated equipment required. Thus these procedures cannot be easily adopted by the majority low-income local farmers in developing countries where a large quantity of SNC is generated. Chemical treatments may also generate unwanted by-products as part of the output material due to side reactions. Finally, cost of removing residual chemicals after chemical treatment of the material could be high as large volumes of solvents are needed. Development of simple, effective

and affordable procedures, such as biological treatments may have to be considered in future studies. Bio-treatments such as microbial bioconversion are environmentally safe relative to chemical procedures.

Conclusion

The results obtained show that SNC generated in shea nut processing industries in Ghana is a potential feed ingredient due to its high values for protein and crude fat. Among the treatments investigated, the NaOH solution pre-treatment was very effective in significantly reducing total tannins and theobromine content of SNC by 69.9% and 25% respectively, thus improving its nutritional value as a livestock feedstuff.

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