Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2013, 5(12):961-970

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Proximate and bio-phytochemical properties of shea nut cake

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ABSTRACT

Shea Nut Cake (SNC) is produced in large quantities as a by-product by shea butter producing industries, 24 samples of SNC were obtained from six industries to examine their proximate, minerals and phytochemical constituents using standard methods. The proximate results indicated that the shea nut cake has 13.03 ± 1.70% crude proteins, 59.37 ± 8.66% carbohydrates, 23.38 ± 10.15% crude fat, 4.25 ± 0.79% ash content, 5.29 ± 0.98% moisture and 8.71 ± 0.85% fibre. The Nitrogen, Potassium, and Magnesium contents of the cake were 2.96 ± 0.39, 4.05 ± 0.62, and 1.43 ± 0.65 mg/kg respectively. The rest of the minerals were Phosphorus 0.22 ± 0.04, Sodium 0.40 ± 0.05, Calcium 0.51 ± 0.09, Copper 0.09 ± 0.0 5, Mercury 0.10 ± 0.56 and Lead 0.13 ± 0.07 mg/kg. The phytochemical screening of extracts of the SNC samples revealed that shea nut cake contains saponins, tannins, alkaloids, terpenoids and reducing sugar. The findings of this research highlight the potential uses of the SNC in the therapeutic industry as well as in other industries.

Key words: Bio-phytochemicals, shea nut cake, mineral, proximate, therapeutic

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INTRODUCTION

Shea nut cake is the residue that remains after the extraction of shea butter from the nut. It is estimated that about 500,000 tons of shea nut cake is produced annually by the shea industry in the savanna zones of Ghana [6]. It is estimated that for every metric tonne nuts processed, 450–600 kg of shea nut cake is produced and about 60,000 metric tonnes of shea kernels are consumed locally in a year [25]. Thus, about 30,300,000 kg shea nut cake is generated locally in a year in Ghana. Meanwhile the industry has been projected to equalize the cocoa industry in future as shea butter gradually becomes the best substitute for the cocoa butter industries [14, 29]. Unfortunately, the shea nut cake which is produced abundantly in Northern Ghana as a by-product is currently being disposed of or being used marginally as fuel [11].

It is a known fact that vigorous research has been conducted into the phenology of the shea tree, its usage and that of the uses of the shea butter extracted from the nuts of the shea fruit [9, 19]. In Ghana, however, no or very little research has been done aimed at expanding the benefits and adding value especially to the by-product of the shea industry. There is, therefore, the need to add value or investigate how the shea nut cake can be converted to a very useful product.

This research investigated the proximate and mineral compositions and phytochemical constituents to fill the academic and economic gaps created by inadequate research into the shea nut cake. This could offer scientific support for the use of the cake as feedstuff in the poultry and animal industries as well as in the fertilizer industries.

EXPERIMENTAL SECTION

SNC samples were collected from four local industries (women groups) and two well established industries in Ghana. The industries were all located in the Northern and Brong-Ahafo Regions of Ghana. The local industries were located at Kalariga, Giso-Naayili Tolon, Gumo, and the mechanized industries were at Savulegu and Techiman all in Ghana.

Three samples each of the first and second extraction cakes were taken from each of the six industries. However, a representative sample was developed out of the three of the first extraction cake and used in the analysis together with the three samples of the second extraction cake. In all, twenty-four (24) shea-nut cake samples (four from each industry) were collected into sterile containers.

Chemical analysis of the shea-nut cake samples

Samples were analyzed for proximate composition using standard methods. Briefly, the dry Matter (DM) was determined after drying in a vacuum oven at 100°C and the Kjeldahl method [3] was used for determination of Crude Protein (CP) after determining the Nitrogen content and multiplying by a factor of 6.25. Crude fat was determined according to AOAC [3] while Fibre content was determined according to Pousga [30] with some modification. The Ether Extract (EE) was determined after acid hydrolysis with the total Ash determined by burning at 550 ± 5ºC for 4 hours. The Atomic Absorption Spectrophotometer (AAS) was used to determine the mineral content of the by-product.

Phytochemical Screening of the Shea Nut Cake

Saponins and terpenoids were determined according to Oseni and Alphonses [21], reducing sugars and tannins according to Oseni and Akwetey [20], coumarins according to Savithrama [26], cynogenic glycosides, flavonoids, anthraquinones and alkaloids were determined according to Adebayo [23] with some modifications.

Statistical analysis

Data were subjected to the ANOVA procedure using the Minitab 15 (2000 version) software. Pair-wise comparisons were made where differences were significant using the Fisher's LSD to compare the effect of industry, type of cake and method of butter extraction on the chemical composition of the SNC.

RESULTS

The data collected after the analysis of the shea nut cake were processed and presented in graphs and tables to explain the results of the experiments. Proximate analysis, mineral, and phytochemical of the shea nut cake samples from the six industries of Northern Ghana were different from what has been perceived of the shea cake as merely a waste product.

Proximate Analysis

The results of proximate analysis carried out on shea nut cake from the six industries are presented in Table 1**.** The values of crude fat ranged from 6.25 to 36.50% with an average of 23.38 ± 10.15%. The fat content was least at GNL-Techiman and highest at Tolon.

Table 1: Proximate qualities of various shea nut cakes from six industries of Northern Ghana

Location	Total Ash%	Moisture%	Crude Protein%	Crude Fat%	Fibre%	Carbohydrate%
Tolon	4.88	4.55	10.37	36.50	9.19	48.26
Kalariga	4.50	5.20	11.85	27.88	8.41	55.61
Gumo	3.75	4.90	12.87	24.63	7.11	59.06
GisoNaayili	3.50	6.50	13.88	26.13	8.96	56.50
Shebu Ind.	3.50	6.45	14.99	18.88	9.35	62.64
GNL	5.38	4.15	14.22	6.25	9.26	74.16
P-Value	0.125	0.006	0.038	0.007	0.311	0.016

Each value is a mean of twenty-four determinations

Total Ash Content

The total ash content presented in Table 1 did not vary significantly among samples across the industries. The total ash content ranged from a minimum of 3.50% at Giso-Naayili and Shebu Industries and a maximum value of 5.38% at the GNL. The total ash content was statistically ($p \geq 0.05$) not different between the local groups and mechanized industries **(**Figure 2**)** although it was higher at the mechanized industry. The second extraction cake contained more total ash than the first extraction cake (Figure 1). The average total ash content for shea nut cake was 4.25 ± 0.79%.

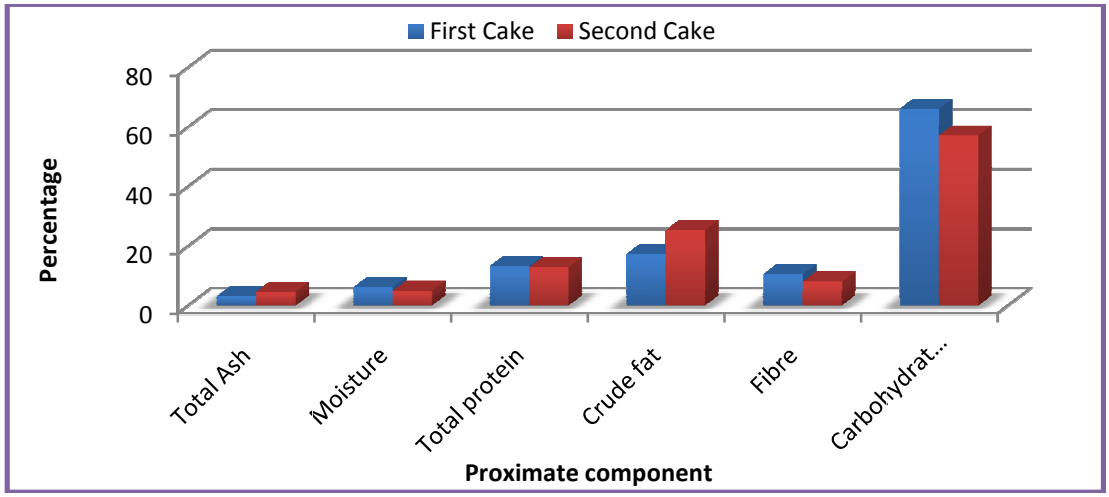

Figure 1: Comparison of proximate traits of shea nut cake derived from first extraction and second extraction

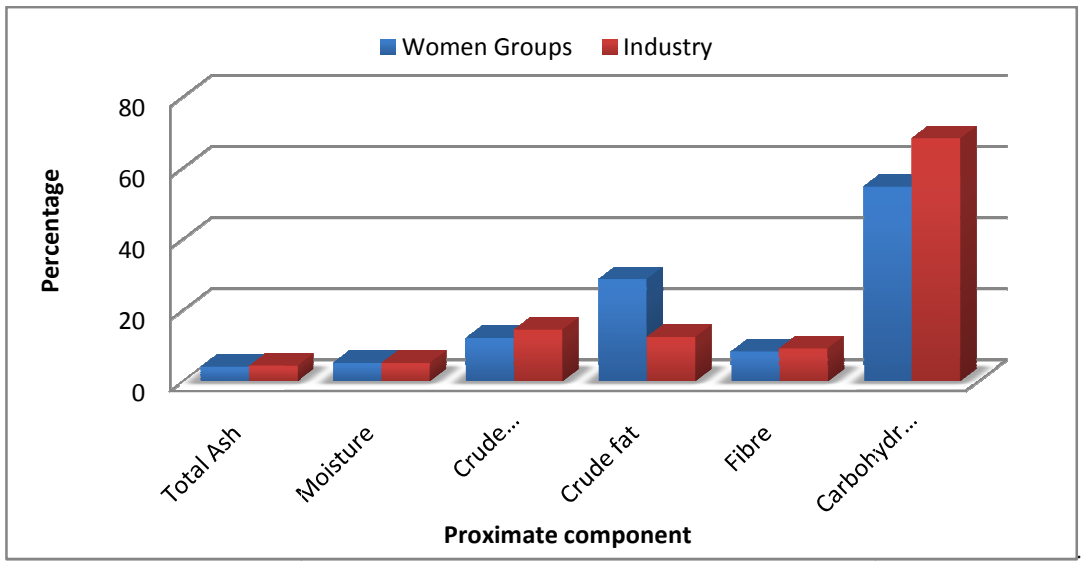

Figure 2: Comparison of proximate traits of shea nut cake derived from traditional and industrial processing methods

Table 2: Mean (±SD) proximate composition of Shea Nut Cake samples

Composition	%(Dry Matter)	P-Value
Crude Protein	13.03 ± 1.70	0.04
Moisture content	5.29 ± 0.98	0.01
Crude Fat	23.38 ± 10.15	0.01
Ash Content	4.25 ± 0.79	0.13
Crude Fibre	8.71 ± 0.85	0.31
Carbohydrates	59.37 ± 8.66	0.02

Each value represents the average of twenty-four determinations ±SD.

Moisture Content

The moisture content is presented in Table 1 alongside other proximate traits. The moisture content was significantly ($P \leq 0.05$) different across samples from the six shea butter processing industries. The least of 4.15% was recorded at the GNL and the highest of 6.50% at Giso-Naayili local industry. Moisture content was higher in the first extraction cake (Figure 1**)** but was not statistically different from the second extraction cake**.** The moisture content was also not statistically ($p \geq 0.05$) different between the local groups and mechanized industries **(**Figure 2). The average moisture content for the shea nut cake in general was 5.29 ± 0.98%.

Crude Protein

Crude protein was significantly ($P \leq 0.05$) different from one industry to the other as elaborated in Table 1. The crude protein content for the two mechanized industries were closer (14.22 and 14.99%) but higher than (10.37 to 13.88%) records at the local industries (Table 1). The crude protein content ranged significantly from 10.37 to

14.99% across the industries. The Women Groups in general produced lower protein content as compared to the industries (Figure 2). Crude protein content between first and second extraction cake was fairly the same (Figure 1). Shea nut cake presented in Table 2 contains 13.03 ± 1.70 percent of crude protein on the average.

Crude Fat

There were significant ($P \leq 0.05$) differences in crude fat content of shea nut cake across the six industries (Table 1 and Figure 2**).** The difference in the crude fat content between first and second extraction cakes was also evident **(**Figure 1**)**. There was about twice as much crude fat in the cake from the women Groups as there were in the mechanized industries (Figure 2). Shea nut cake from the results presented in Table 2 contains 23.38 ± 10.15 % of crude fat on the average.

Crude Fibre

The statistical analysis of the crude fibre content indicated that it was not different ($P \geq 0.05$) across the various industries. The crude fibre content ranged from 7.11 at Gumo, a local industry to 9.35% at Shebu, a mechanized industry. Crude fibre content was higher in the first extraction cake (Figure 1). The crude fibre content was statistically not different ($p \geq 0.05$) between the local groups and mechanized industries **(**Figure 2). Shea nut cake from the results presented in Table 2 contains 8.71 ± 0.85 percent of crude fibre on the average.

Carbohydrates

Carbohydrates were high in the SNC obtained from mechanized industries than the local industries and as a result it was significantly ($P \leq 0.05$) different across the shea industries (Table 1). The carbohydrates content ranged from the least of 48.26% at Tolon and a maximum of 74.16% at the GNL. Analysis based on first and second extraction cake showed that there were more carbohydrates in the former than there were in the latter (Figure 1). Further analysis of the shea cake samples indicated that there were more carbohydrates in shea cake samples from the mechanized industries than there were in the local industry (Figure 2).

Mineral Analysis of shea nut cake

Table 3: Mean mineral composition of shea cake (%DM ± SD) mg/kg from six industries of Northern Ghana

Sample	Tolon	Kalariga	Gumo	GisoNaayili	Shebu In	GNL
Nitrogen	2.370 ± 0.649	2.693 ± 0.437	2.873 ± 0.141	3.173 ± 0.450	3.425 ± 0.375	3.250 ± 0.513
Phosphorus	0.155 ± 0.010	0.205 ± 0.044	0.225 ± 0.019	0.240 ± 0.035	0.260 ± 0.020	0.230 ± 0.037
Potassium	2.915 ± 1.143	4.115 ± 0.864	4.160 ± 0.852	3.973 ± 0.906	4.710 ± 0.390	4.428 ± 0.888
Sodium	0.345 ± 0.158	0.380 ± 0.103	0.363 ± 0.076	0.385 ± 0.096	0.468 ± 0.062	0.430 ± 0.079
Calcium	0.435 ± 0.130	0.420 ± 0.102	0.455 ± 0.124	0.490 ± 0.140	0.575 ± 0.136	0.665 ± 0.141
Magnesium	1.995 ± 0.544	1.668 ± 0.468	2.253 ± 1.330	1.208 ± 0.342	0.860 ± 0.534	0.618 ± 0.413
Copper	0.038 ± 0.010	0.093 ± 0.037	0.183 ± 0.117	0.088 ± 0.035	0.103 ± 0.015	0.058 ± 0.026
Mercury	0.060 ± 0.091	0.076 ± 0.052	0.049 ± 0.078	0.060 ± 0.100	0.170 ± 0.075	0.196 ± 0.012
Lead	0.010 ± 0.00	0.188 ± 0.210	0.200 ± 0.077	0.133 ± 0.075	0.108 ± 0.015	0.123 ± 0.050

DM –dry matter, SD – standard deviation

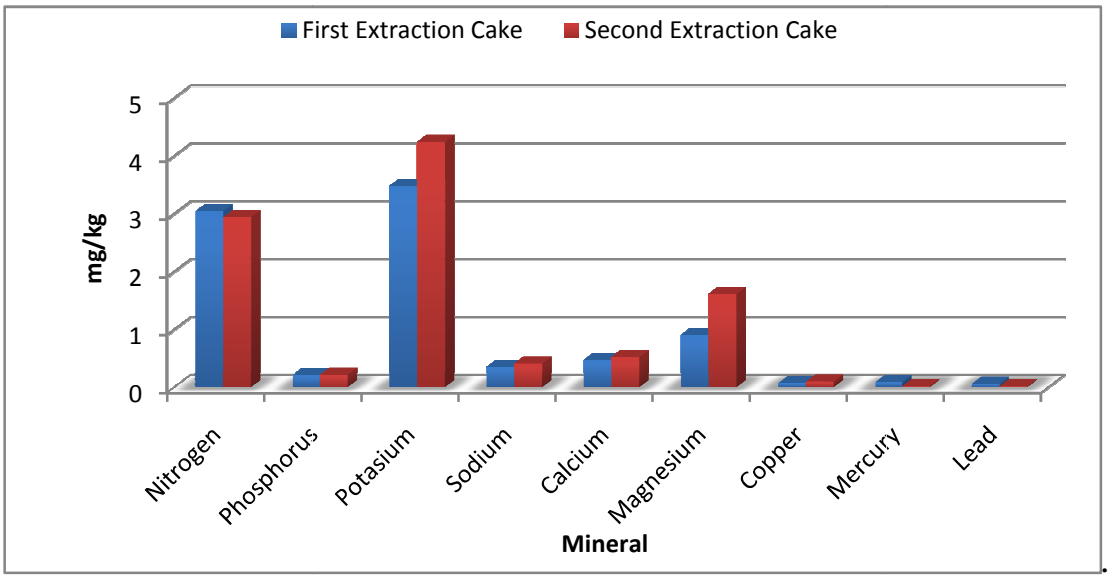

Figure 3: Comparison of mineral composition of shea nut cake derived from first and second extractions

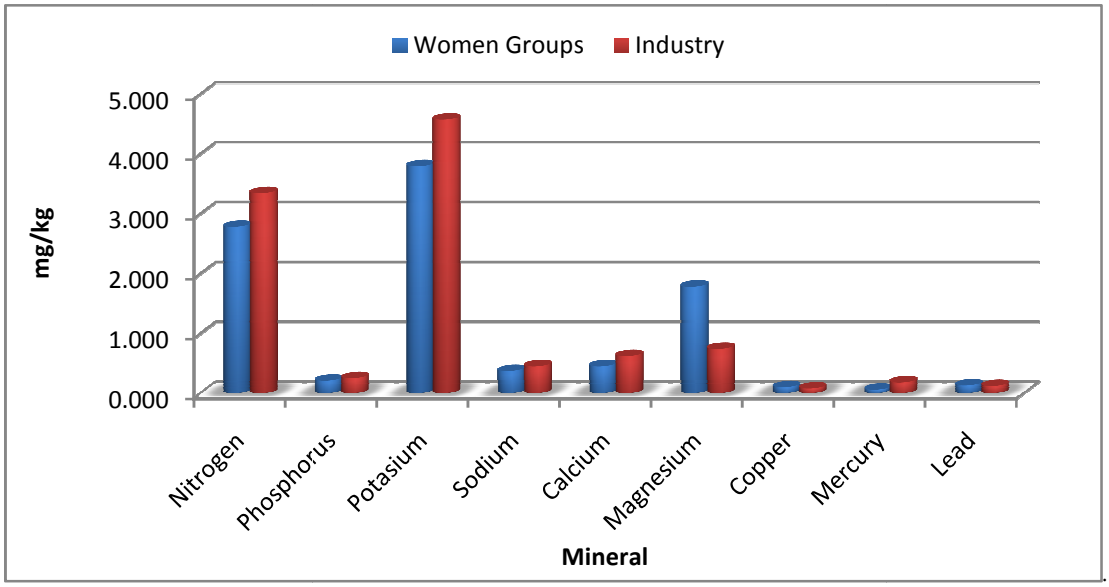

Figure 4: Comparison of mineral composition of shea nut cake derived from traditional and mechanized processing

Table 4: Mean (±SD) mg/kg mineral composition of shea nut cake

Mineral	Mean ± SD(mg/kg)	P-Value
Nitrogen	2.96 ± 0.39	0.038
Phosphorus	0.22 ± 0.04	0.001
Potassium	4.05 ± 0.62	0.128
Sodium	0.40 ± 0.05	0.552
Calcium	0.51 ± 0.09	0.472
Magnesium	1.43 ± 0.65	0.022
Copper	0.09 ± 0.05	0.020
Mercury	0.10 ± 0.56	0.056
Lead	0.13 ± 0.07	0.533

Each value is a mean of twenty-four determinations ±SD.

Nitrogen content (N)

The analysis of variance for nitrogen content in shea nut cake from different shea industries was significantly ($P \leq 0.05$) different across the industries as indicated in Table 4. The minimum recorded amount for Nitrogen was 2.370 ± 0.649 mg/kg at Tolon compared to a maximum value of 3.425 ± 0.375 mg/kg (Table 3) at Shebu industries. The analysis of nitrogen content based on type of industry indicated that it was higher at the mechanized industry (Figure 4) but on the basis of type of sample it was higher in the first extraction cake (Figure 3). The nitrogen content (3.425 ± 0.375 mg/kg) was highest at Shebu Industry and was closely followed (3.250 ± 0.513 mg/kg) by the GNL (Table 3) – the two mechanized industries. The average nitrogen content was 2.96 ± 0.39 mg/kg.

Phosphorus content (P)

Phosphorus was slightly higher at the mechanized industries as compared to the local industries (Figure 4) and as a result it was significantly different ($P \leq 0.05$) across the shea industries (Table 3). The phosphorus content ranged from the least of 0.155 ± 0.010 mg/kg at Tolon and a maximum of 0.260 ± 0.020 mg/kg at the Shebu industry. There was similar amount of Phosphorus in the first and second extraction cakes (Figure 3). The phosphorus (0.26 ± 0.02 mg/kg) content was highest at Shebu Industry and closely followed by GNL (Table 3**)**.

Potassium content (K)

The potassium content presented in Table 3 did not vary significantly among samples across the industries. The potassium content ranged from a minimum of 2.915 ± 1.143 mg/kg at Tolon and a maximum value of 4.710 ± 0.390 mg/kg at Shebu industry. The Potassium content was statistically not different ($p \geq 0.05$) between the local groups and mechanized industries **(**Figure 4**)** although it was higher at the mechanized industry. The second extraction cake contained more Potassium than the first extraction cake (Figure 3). The average Potassium content for shea nut cake was 4.05 ± 0.62 mg/kg.

Sodium content (Na)

The analysis of variance for sodium content in shea nut cake from different shea industries was not different ($P \geq 0.05$) as indicated in Table 4. The minimum recorded amount for sodium was 0.345 ± 0.158 mg/kg at Tolon which

rose to a maximum value of 0.468 ± 0.062 mg/kg at Shebu industries. The results for Mineral analysis indicated that the sodium content of the cake were not different ($P \geq 0.05$) across the six shea industries (Tables 3 and 4). The Sodium (0.468 ± 0.062 mg/kg) content was highest at Shebu Industry and closely (0.430 ± 0.079 mg/kg) followed by GNL (Table 3).

Calcium content (Ca)

The statistical analysis of the calcium content indicated that it was not different ($P \geq 0.05$) across the various industries. The calcium content ranged from 0.420 ± 0.102 mg/kg at Kalariga, a local industry to 0.665 ± 0.141 mg/kg at the GNL, a mechanized industry. Calcium content was lower in the first extraction cake (Figure 3). The calcium content was statistically not different ($p \geq 0.05$) between the local groups and mechanized industries **(**Figure 4). Shea nut cake from the results presented in Table 4 contains 0.51 ± 0.09 mg/kg of calcium on the average.

Magnesium content (Mg)

Magnesium was significantly different ($P \leq 0.05$) from one industry to the other as was presented in Table 4. The Magnesium content for the two mechanized industries each was less than one (0.860 and 0.618 mg/kg) but lower than values at the local industries (Table 3). The Magnesium content ranged significantly from 0.618 ± 0.413 to 2.253 ± 1.330 mg/kg across the industries. The Women Groups in general produced higher Magnesium content as compared to the industries (Figure 4). Magnesium content was also higher in the second than the first extraction cake (Figure 3). Shea nut cake from the results presented in Table 4 contains 1.43 ± 0.65 mg/kg of Magnesium on the average.

Copper content (Cu)

The statistical results for all minerals including that of copper content were presented in Tables 3 and 4. The results obtained for copper content across the industries indicated that it was significantly ($P \leq 0.05$) different. Shea nut cake had an average of 0.094 mg/kg copper content **(**Table 4**)**. The copper content ranged from 0.038 ± 0.010 mg/kg at Tolon to 0.183 ± 0.177 mg/kg at Gumo **(**Table 3). The concentration of copper in the first extraction cake was not different from that of the second extraction cake as shown in Figure 3. In a similar manner, the copper content was not different between local and mechanized industries **(**Figure 4).

Mercury content (Hg)

Values obtained for Mercury across the industries were all different ($P \leq 0.05$) as in Table 3 and 4. The mercury content ranged from 0.049 ± 0.078 at Gumo to 0.196 ± 0.012 mg/kg at GNL (Table 3). The concentration of mercury in the first extraction cake was higher than that of the second extraction cake (Figure 3). In a similar manner, the copper content was higher in the mechanized industries compared to the local industry **(**Figure 4). Shea nut cake had an average of 0.102 mg/kg mercury content (Table 4).

Lead content (Pb)

The statistical examination of lead content is presented in Tables 3 and 4 alongside other minerals. The results obtained for lead content across the industries indicated that it was not significantly different ($P \geq 0.05$). Shea nut cake had an average of 0.13 ± 0.07 mg/kg Lead content (Table 4). The Lead content ranged from 0.010 ± 0.00 mg/kg at Tolon to 0.200 ± 0.077 mg/kg at Gumo (Table 3). The concentration of lead in the first extraction cake was higher but not statistically different from that of the second extraction cake as shown in Figure 3. The Lead content was not different statistically between local and mechanized industries (Figure 4).

Phytochemical constituents of shea nut cake

Phytochemical screening of samples from all the industries revealed that saponins, tannins, alkaloids, terpenoids and reducing sugars were present in the shea nut cake extracts (Table 5). Coumarins, flavonoids, anthraquinones and cynogenic glycosides were absent in the by-product.

Table 5: Phytochemical constituents of shea nut cake from six shea industries of Northern Ghana

Sample Location	Tolon	Kalariga	Gumo	GisoNaayili	Shebu Industry	Ghana Nuts Limited
Saponins	+	+	+	+	+	+
Tannins	+	+	+	+	+	+
Reducing Sugars	+	+	+	+	+	+
Cynogenic Glycosides	-	-	-	-	-	-
Anthraquinones	-	-	-	-	-	-
Alkaloids	+	+	+	+	+	+
Flavonoids	-	-	-	-	-	-
Terpenoids	+	+	+	+	+	+
Coumarins	-	-	-	-	-	-

+ = present, − = absent

DISCUSSION

Shea nut cake (SNC) is a brown amorphous substance released as waste during shea butter processing and has not been used extensively for any form of benefit. The substance is apparently thrown out as waste. The by-product is composed of proximate constituents, minerals, and phyto-chemical components. The quality of the shea nut cake is determined by the levels of constituents of each of these four parameters.

Shea nut cake contained a host of useful chemical substances and this is evident across the industries. The total ash content (Table 1) which predicts the mineral composition of the shea nut cake was not significantly different ($P \geq 0.05$) across the industries but appear higher in the second extraction cake as compared to the first. What this could mean is that, especially for the local industry, the number of low density metal oxides in the cake was high since the crude shea butter from which the second cake was obtained, floated on the water.

Across the local and mechanized industries (Figure 2) the ash contents were similar and this suggests that the mineral contents are not different statistically. The average ash content of shea nut cake according to this research was 4.25 ± 0.79 %. This value is lower than what was recorded for shea nut (6.1%) by Pousga [30]. However this value is similar to the ash content of 'Kuli kuli'-groundnut cake and 'eri'-by-product of soyamilk as was investigated by Ogbannya [8].

Crude fat was higher in the second extraction cake (Figure 1); a phenomenon difficult to explain by the methods employed in the mechanized industries but could easily be explained by the traditional method of butter extraction. The gross phenomenal disparity in crude fat content (Table 1) across the industries, therefore, could be attributed to the shea butter extraction method adopted by each industry. It was observed in the present study, that the traditional method left as much as five (5) times crude fat (28.79% mean value of crude fat from local industries) in the shea nut cake as compared to the combined methods of mechanical press with chemical methods (6.25%) employed at the Ghana Nuts Limited (GNL) (Table 1). The local industry at Tolon adopts the local traditional method of shea butter extraction which achieves about 25% of butter extraction [25] while the mechanical with chemical methods have achieved about 98% extraction efficiencies [4]. Although the Tolon, Kalariga, Gumo and Giso-Naayili all adopted the traditional method of butter extraction, there were remarkable differences in the crude fat content of the cake across the local industries. This undoubtedly exposes the arbitrary nature of the methods used at the various local setups.

The first extraction cake had high moisture, protein, fibre and carbohydrates content possibly due to the fact that it received lesser heat (Figure 1). The protein, the fibre and carbohydrates contents were also high at the mechanized industries where the nuts had not been exposed to extreme heat (15-20^{o}C) unlike processes adopted by the women groups. This supports why the same constituents were high with the first extraction cake (Figure 1) which had not been exposed to extensive heat in the extraction process. These parameters: the protein, the fibre and carbohydrates contents were lower in the second extraction cake samples of the local industry because they had undergone four different heating sessions: sun drying, parboiling, dry frying and boiling to skim the oil. The protein molecules some of which might have been lost and the glycosidic linkages in the dietary fibre polysaccharides could have also been broken and consequently the low contents recorded for each of them.

The proximate composition of the shea nut cake is comparable to works of other researchers. Differences in fat content of shea cake across the industries do not agree with findings by Pousga [30] who found fat content to vary across two climatic zones of Burkina Faso. The present findings of crude fat levels (6.25% – 36.5%) were much higher than 5.3%–9.6% recorded by Pousga [30]. The differences in fat levels could be attributed to the differences in approach (the pre-treatment, the care and attention at every stage of the process) of oil extraction and the level of efficiencies reached. This was also likely indicative of the differences in fat levels of the shea trees due to their genetic disparities or probably due to their different geographical and ecological zones [30]. Ugese [13] also reported similar low figures (2.8%–4.0%) of crude fat levels for shea nut cake. It presupposes, therefore, that if the crude fat levels could reach values as high as 36.5% at the local industry, then their extraction efficiency do not commensurate of their efforts.

The range of values for protein (10.37–14.99%) from our study of the shea cake in Ghana is different from what was reported by Pousga [30], (2.5–10.3%) and Ugese [13] (7.6–10.1%). However, their carbohydrate values were (89.1–97.3%) and (58.4–71.9%) respectively and the present findings (48.26 – 74.16%) fell within the same range (58.4 – 71.9%) obtained by Ugese [13].

The fibre content (7.11–9.35%) of Shea nut cake as reported in the present study (Table 1) appeared to be within the range (7.8–11.0)% to what was reported by Pousga [30] but was lower than values (9.9–19.3%) recorded by Ugese

[13]. The International Centre for Research in Agro-forestry [15] reported that although shea nut cake was already being used as a livestock and poultry feed, one key disadvantage of its use was the presence of tannins which exhibit a bitter taste even though the levels have not been quantified. Umali [7] has also reported the presence of anti-nutritional factors and low digestibility on shea nut cake and noted them as setbacks that need to be overcome for it to be fully used as feed. The present findings unearthed excellent proximate traits of Ghanaian shea nut cake and support their potential significance in the animal feed industry in Ghana.

The mineral content of the shea cake is promising. Nitrogen, potassium and magnesium were high across the industries (Table 2) and they were followed by phosphorus, sodium and calcium. These are all useful minerals for supporting the life of plants in the agricultural sector. In addition to other qualities, the heavy metal load of the cake was fairly reasonable for use in compost development for agricultural purposes. William [12] reported that the recommended metal limits for heavy metal use of compost is 75, 50 and 0.5 mg/kg for lead (Pb), copper (Cu) and mercury (Hg) respectively. This present study found 0.09 mg/kg, 0.10 mg/kg and 0.13 mg/kg for Cu, Hg and Pb respectively (Table 9).

Sodium is known to facilitate and maintain the fluid balance of the body and promotes the normal functioning of the body nerves and muscles (Mohammad, 2009). The sodium content (0.46 mg/kg) found in this present study is higher than what (0.05 mg/kg) was reported by Pousga [30] for shea nut cake. Among other by-products, the sodium content of shea nut cake compares well with that of cotton seed cake (0.35 mg/kg) but higher than that of sorghum beer residue (0.06 mg/kg) [30].

The potassium content in shea nut cake across the industries was generally high and comparatively higher (4.05 mg/kg) than the mean value (0.54 mg/kg) determined by [30]. The present findings also indicate that shea nut cake has higher potassium content than cotton seed (1.8 mg/kg) and sorghum beer residue (0.11 mg/kg), [30]. Potassium plays a significant role in protein synthesis in addition to its involvement in the functioning of cell organelles [5] and it is also noted for the life supporting role it plays for plants.

Magnesium is generally required for healthy bones and muscles and the functioning of many enzymes in living systems [17]. The present study reveals that shea nut cake has high magnesium content (1.43 ± 0.65 mg/kg) as compared to (0.15 mg/kg) observed by Pousga [30]. The Magnesium content which was lower in the Mechanized industries suggests that the source of Magnesium in the shea nut cake was different for the local and mechanized industries.

The calcium and phosphorus contents of shea nut cake according to the findings of the present research (0.51 mg/kg and 0.22 mg/kg respectively) are concordant with the findings of Pousga [30]. Whereas the calcium content was comparatively high compared to values for both cotton seed cake (0.34 mg/kg) and sorghum beer residue (0.14 mg/kg), phosphorus in the shea nut cake was lower than cotton seed cake (1.3 mg/kg) and sorghum beer residue (0.25 mg/kg).

Heavy metals when ingested into humans and other animals have detrimental effects on health. Some heavy metals such as lead and mercury have been distinguished as likely toxic elements especially within some specific restraining values, and are known as latent risk for human diet [16].

The lead content of the shea nut cake across the industries is very uniform which suggests that the metal is coming from a common source. The highest occurrence of the metal was 0.200 ± 0.077 mg/kg and the average lead content of shea nut cake was 0.13 ± 0.07 mg/kg. This value is below the EU permissible level of lead concentration (0.2 mg/kg) for most plant products and cereals [5] (Table 3).

Mercury content was high in the mechanized industries and this presupposes that the source of mercury contamination of the shea nut cake at the mechanized centres was different from the local industries. The sources of mercury are marine, fruit nuts, farm animals, cereals and dairy products [27, 22]. The average mercury content of shea nut cake observed was 0.10 ± 0.56 mg/kg.

The copper content was generally inconsistent across the industries, and across the first and second extraction cakes. The mean copper content of shea nut cake was 0.09 ± 0.05 mg/kg. There has not been any documented standard set for copper content of shea nut cake. The tolerance level of copper in edible oil at Taiwan, for instance, is set at 0.4 mg/kg according to the standard of edible oils announced by the Department of Health in 1993 [31]. Copper is an essential element for the maintenance of body functions and not a hazardous metal since it does not induce adverse symptoms on human when consumed in trace amounts [31]. The harmful effect only occurs when it is overdosed.

The SNC has five of nine phytochemicals in this study (Table 5) when samples screened for their presence. Saponins, tannins, reducing sugars, alkaloids and terpenoids were present in the SNC. The medicinal value of plants and plant products lies in some chemical substances that produce a definite physiological action on the human body [23] and phytochemicals are the basic source for the establishment of several pharmaceutical industries [26].

Alkaloids were present in the shea nut cake across the industries (Table 5) and alkaloids have been reported to have higher anticancer activities [32]. Alkaloids are also known to have anti-microbial, antifungal and anti-inflammatory effects [10]. Sofowora [1] indicated in a study that alkaloids are anti-hypertensive agent. Terpenoids and triterpenoids in particular have demonstrated antibacterial activities [24]. Tannins were also present in the shea nut cake and Dharmananda [28] reported that tannins are extensively used for the treatment of intestinal disorders such as diarrhoea and dysentery. The treatment of sore throat, haemorrhage and wound healing has been linked to tannins [10]. Saponins were observed in all the samples across the shea industries. They are known to possess anti carcinogenic properties and other health benefits [18]. Saponins could also play an essential role in the treatment of malaria [2]. The phytochemical analysis also revealed the presence of reducing sugars in all the extracts confirming the presence of carbohydrate. Sugars are mostly monosaccharide and disaccharides and reducing sugars in particular play an important role in energy generation.

CONCLUSION

The high nitrogen (2.96 mg/kg), potassium (4.05 mg/kg) and magnesium (1.43 mg/kg) contents make shea nut cake ideal for use as manure and for fertilizer production. Also the presence of essential phytochemicals such as saponin, tannins, reducing sugars, alkaloids and terpenoids in the SNC widens its application in therapeutic remedies.

Acknowledgements
The authors wish to acknowledge the Ghana Education Trust Fund (GETFund) for the financial support for this research.

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