Nutritional value of Shea Butter (Vitellaria paradoxa) seed Meal (SBSM) as affected by different days of Natural fermentation

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Abstract

A laboratory studies were carried out to investigate the effect of fermentation duration on nutrients and anti-nutrient composition of shea butter seed meal, SBSM. 500g of the wet unprocessed SBM was cooked for 1 hour after which it was cooled and divided into 5 portions. The first portion was tagged T1 and oven-dried. The remaining 4 were bagged in different air-tight polythene bags and allowed to ferment for 3, 4, 5 and 6 days and each treatment was labeled as T2, T3, T4 and T5, respectively. At the end of the processing, each treatment was replicated and the samples analyzed. Crude protein and ether extract were significantly ($P<0.05$) improved as the days of fermentation increased. The values increased from 10.33 and 2.76% to 15.58 and 4.50%, respectively at day 3 fermentation. However, the values reduced as fermentation entered day 5 and 6. Fermentation of SBSM for up to day 4 (T5) and 5 (T6) gave the best ($P<0.05$) result for crude fibre (14.37 and 14.78%), whereas fermentation for as early as 3 days gave same result for ash as compared to those of day 4 (4.48%), 5 (3.29%) and 6 (3.11%), respectively. Similarly, fermenting SBSM for up to 4 days gave significantly ($P<0.05$) the highest value for gross energy (3.13 kcal/kg) whereas that of day 5 produced the highest value of NFE (63.51%) but similar to that of day 2 (61.98%). There was no significant ($P>0.05$) variation in the value recorded for DM across the treatments. Consistently, the best ($P>0.05$) result obtained for all the minerals evaluated were on the fourth day of fermentation except for days 3 (0.06%) and 6 (0.04%) which were comparable to both the control (0.09%) and day 4 (0.09%). Fermenting SBSM for up to day 4 gave the best ($P>0.05$) result for potassium (0.36%), calcium (0.18%) and phosphorus (0.36%). However, the treatment did not ($P<0.05$) affect the concentration of magnesium. Saponin and phytic acid were significantly ($P<0.05$) reduced due to fermentation for 3 to 4 days but were increased ($P<0.05$) beyond this duration of fermentation. However, there was no variation ($P>0.05$) in the results obtained for tannin (0.001 – 0.003%), oxalate (0.0010 – 0.0014%) and flavonoids (0.005 – 0.006%). The vitamins analyzed namely A, B6 and α-tocopherol were consistently improved ($P<0.05$) from the beginning of the time of fermentation up to day 4 but reduced ($P<0.05$) beyond this period of fermentation. Monogastric animal farmers can therefore, ferment SBSM for at most 4 days and conveniently feed their animals as a replacement for conventional energy source.

Key words: Shea Butter Seed Meal, Fermentation Duration, Proximate Compositions, Amino Acids and Anti-nutritional factors

Introduction

Shea butter (*Vitellaria paradoxa*) seed meal is a product that is obtained by chopping the seed and afterwards, either sun dried or cooked before being used as feed for animals or for extraction of fat from the nuts. It is available in large quantities in West Africa. It has similarities in its nutrient compared to wheat feed (NRC, 1994) and other non-conventional feedingstuffs (Alu *et al.,* 2018).

According to Canibe *et al.* (2006) as cited by Jiankun Hu *et al.* (2008), fermentation is widely used to produce healthy foods for people and animals and its interest in its application in animal feeding is increasing due to the total ban on antibiotic growth promoters in the European Union. The authors also noted that the application of fermentation technology in animal feeds can be categorized into that involving fermented raw materials and that involving fermented liquid feed. Raw materials such as soybean and soybean meal (Hong *et al.,* 2004; Cho *et al.,* 2007; Kim *et al.,* 2007), cottonseed meal (Zhang *et al.,* 2006), barley (Canibe and Jensen, 2007), wheat (Canibe and Jensen, 2007) and farm by-products (Oboh and Akindahunsi, 2005; Ramli *et al.,* 2005; Oduguwa *et al.,* 2007) can be fermented, with the aim of eliminating anti-nutritional factors such as gossypol in cottonseed meal (Zhang *et al.,* 2006) and trypsin inhibitor in soybean meal (Hong *et al.,* 2004), improving nutrient digestibility (Cho *et al.,* 2007; Kim *et al.,* 2007) and enriching the quality of protein (Oduguwa *et al.,* 2007). Then the fermentation end products can be incorporated into diets as feed ingredients.

According to Matthew and Alu (2016), shea butter cake is a non-conventional feed resource and it is not consumed by man and presently regarded as waste. It is, unlike other conventional energy sources, which has low human food preference; hence might be a very good substitute; but has some anti-nutritional factors like tannins and saponins that could limit its usage in poultry nutrition.

Most of the conventional feedstuffs for poultry are very expensive and in high demand by human beings and industrial users for consumption and usage respectively. Shea butter cake unlike other conventional energy sources has low human food preference; hence might be a very good substitute; but it has some anti-nutritional factors that could limit its usage in poultry.

The use of non- conventional feed ingredient and the search for other feed resources that are not expensive is therefore necessary (Farinu *et al*., 2006). Non-conventional feedstuff offers the best alternative into our environment for a reduction in feed cost (Dafwang *et al.,* 2001*).* In terms of total cost, energy is the main factor influencing diet cost (Afolayan *et al.,* 2009). However, according to Vantsawa (2001), the high cost of maize had led to high cost of poultry feeds. Surprisingly, energy sources (grains) had turned out to be more expensive, thereby increasing the cost of production (Abeke *et al*., 2003 and Bawa *et al.,* 2003). The aim of this study is therefore; to evaluate the effect of fermentation duration on nutrient and anti-nutrient composition of shea butter seed meal with the view to feeding monogastric animals.

Materials and Methods

The experiment was carried out in the Biochemistry Laboratory of the Department of Animal Science, Faculty of Agriculture, Nasarawa State University, Keffi, Shabu-Lafia Campus.

Sources of SBSM

The SBSM was obtained from villages around Shabu in Lafia of Nasarawa State, Nigeria.

Fermentation

500g of the wet unprocessed SBSM was cooked for 1hour after which it was cooled and divided into 5 portions. The first portion was tagged T1 and oven-dried. The remaining 4 were bagged in different air-tight polythene bags and allowed to ferment for 3, 4, 5 and 6 days and each treatment was labeled as T2, T3, T4 and T5, respectively. At the end of the processing, each treatment was replicated and samples were taken for analysis.

Biochemical analysis

Proximate analyses of the samples of milled differently processed SBSM were carried out at the IAR&T, Moor Plantation, Ibadan, Nigeria, using the procedure outlined by Galyean (2010). Dry matter (% DM) was calculated as the 100 minus the percent moisture content while the nitrogen free extract (%NFE) was calculated by difference; using the formula:

$$NFE = 100 - (\%CP + \%CF + \%EE + Ash + \%\ Moisture).$$

Determination of vitamins, minerals and amino acid

For the determination of vitamins and mineral profile, 0.5g of each wet digested samples of Shea butter meal was analyzed by the method described by AOAC (2012). The Technicon Sequential Multi-sample Aminoacid analyzer (TSM)– Model DNA 0209 was used to determine the profile of the aminoacids according to the methods outlined by Speckman *et al.* (1958).

Determination of phytochemicals

Phytic acid determination was done according to the modified method described by Wheeler and Ferrel (1971) and Steward (1974) while trypsin inhibitor activity was determined according to the methods described by Gupta and Deodhar (1975) and Hammerstr and *et al.* (1981). The methods share the same principles of determining trypsin inhibitors in soybeans products based on the tryptic hydrolysis of the synthetic substrate, benzoyl-DL-arginine-nitroanilide (BAPA).

The Spectrophotometric method of Brunner (1984) was used for saponin analysis of tannin while oxalate was determined using the methods outlined by Swain (1979). The method of estimation of tannin content in extract by Joslyn (1970) was used for the determination of tannin content in the samples. Finely ground sample (0.5 g) was defatted with 5% ethyl ether for 15 min. The tannin in the defatted sample was then extracted with methanol and the absorbance at 760 nm was measured.

Experimental design

The experimental design was a Completely Randomized Design and the following statistical model was used:

Yij = U+T1+€ij, Where Yij= is the individual observation, U is the Population Mean, T1 is the Treatment Error and €ijis the Random error.

Statistical analysis

All the data collected were statistically analyzed using the general linear model of Statistical Analysis System (SAS, 2008).

Results and Discussion

Effect of fermentation duration on proximate composition of SBSM

The result of the effect of fermentation duration on proximate composition of SBSM is presented in Table 1.Crude protein and ether extract were significantly (P<0.05) improved as the days of fermentation increased. This is noticed as the values increased from 10.33 and 2.76% to 15.58 and 4.50%, respectively at day 3 of fermentation. However, the values reduced as fermentation entered day 5 and 6. Fermentation of SBSM for up to day 4 (T5) and 5 (T6) produced the highest (P<0.05) result for crude fibre (14.37 and 14.78%) whereas fermentation for as early as 3 days gave same result for ash as compared to those of day 4 (4.48%), 5 (3.29%) and 6 (3.11%), respectively. The values obtained for crude protein (6.18 to 15.58 %) in the present study are higher than those earlier (5.56 to 9.38 %) reported by Matthew and Alu (2016) for shea butter meal and were close to that of maize. A similar trend was recorded for ether extract, crude fibre, NFE and gross energy as earlier reported (Alu, 2016).

Similarly, fermenting SBSM for up to 4 days gave significantly (P<0.05) the highest value for gross energy (3.13 kcal/kg) whereas that of day 5 produced the highest value of NFE (63.51%) but similar to that of day 2 (61.98%). This high value of NFE implies that the test ingredient is rich in carbohydrate (Mcdonald *et al.* 1995). There was no significant (P>0.05) variation in the value recorded for DM across the treatments. However, the low level of moisture content is an indication of better keeping quality of the test ingredient as compared to other non-conventional feeding stuffs.

Table 1. Effects of fermentation duration on proximate composition of SBSM

Parameters	T1	T2	T3	T4	T5	LOS
Crude protein (%)	15.23±0.63^{a}	10.33±5.73^{ab}	15.58±0.14^{a}	6.18±0.41^{b}	7.44±1.92^{b}	*
Ether extract (%)	4.53±0.16^{a}	2.76±1.13^{b}	4.50±0.11^{a}	1.97±0.14^{b}	2.41±0.66^{b}	*
Crude fibre (%)	6.38±0.10^{b}	10.06±6.13^{ab}	6.27±0.13^{b}	14.37±1.27^{a}	14.78±0.61^{a}	*
Ash (%)	3.75±1.10^{a}	3.50±0.75^{a}	4.48±0.35^{ab}	3.29±0.11^{a}	3.11±0.25^{a}	*
Dry matter (%)	90.35±0.62	88.26±2.40	90.44±0.28	89.31±0.57	88.38±2.34	NS
GE (kcal/kg)	3.32±0.25^{a}	1.91±0.01^{b}	3.13±0.04^{a}	1.96±0.20^{b}	1.92±0.01^{b}	*
NFE (%)	59.72±0.31^{b}	61.98±0.40^{ab}	59.57±1.36^{b}	63.51±1.36^{a}	60.88±0.77^{b}	*

GE= Gross energy, LOS= Level of significance, a,b= means on the same row bearing different superscripts differ significantly, *=Significant at 5% (P<0.05), NS= Not significant at 5% (P>0.05).

Effect of fermentation duration on mineral concentration of SBSM

The result of the effect of fermentation duration on mineral concentration of SBSM is presented in Table 2. Consistently, the best (P>0.05) result obtained for all the minerals evaluated were on the fourth day of fermentation except for days 3 (0.06%) and 6 (0.04%) which were comparable to both the control (0.09%) and day 4 (0.09%). Fermenting SBSM from days 1 and 4 gave the best (P>0.05) results for potassium, calcium and phosphorus. However, the treatment

Table 2: Effects of fermentation duration on mineral composition of SBSM

Parameters	T1	T2	T3	T4	T5	LOS
Sodium (%)	0.09±0.01^{ab}	0.06±0.05^{ab}	0.09±0.00^{a}	0.03±0.01^{b}	0.04±0.01^{ab}	*
Potassium (%)	0.36±0.02^{a}	0.19±0.00^{b}	0.28±0.12^{ab}	0.18±0.01^{b}	0.20±0.01^{b}	*
Calcium (%)	0.18±0.01^{ab}	0.16±0.04^{ab}	0.18±0.00^{a}	0.13±0.00^{b}	0.14±0.01^{ab}	*
Phosphorus (%)	0.35±0.02^{ab}	0.29±0.04^{ab}	0.36±0.00^{a}	0.22±0.00^{ab}	0.21±0.01^{b}	*
Magnesium (%)	0.27±0.02	0.24±0.04	0.27±0.01	0.22±0.00	0.22±0.01	NS

LOS= Level of significance, a,b= means on the same row bearing different superscripts differ significantly *=Significant at 5% (P<0.05), NS= Not significant at 5% (P>0.05).

Table 3: Effects of fermentation duration on phytochemical constituents of SBSM

Parameters	T1	T2	T3	T4	T5(Day 6)	LOS
Tannin (%)	0.003±0.001	0.002±0.001	0.003±0.000	0.002±0.000	0.001±0.001	NS
Saponin (%)	0.145±0.002^{b}	0.132±0.015^{b}	0.129±0.006^{b}	0.243±0.006^{a}	0.254±0.004^{a}	*
Phytate (%)	0.011±0.001^{c}	0.013±0.001^{abc}	0.012±0.001^{bc}	0.014±0.001^{ab}	0.015±0.001^{a}	*
Oxalate (%)	0.010±0.002	0.014±0.002	0.012±0.003	0.013±0.001	0.014±0.001	NS
Flavonoids (%)	0.006±0.001	0.005±0.003	0.006±0.000	0.006±0.002	0.006±0.005	NS
TIA (TUI/mg)	5.430±0.057^{a}	3.755±0.001^{ab}	5.370±0.057^{a}	2.460±0.090^{b}	2.310±0.226^{b}	*

LOS= Level of significance, a,b,c = means on the same row bearing different superscripts differ significantly *=Significant at 5% (P<0.05), NS= Not significant at 5% (P>0.05), TIA-Trypsin inhibitor activity.

Effect of fermentation duration on vitamins composition of SBSM

The vitamins analyzed (Table 4) namely A, B_6 and α-tocopherol were consistently improved (P<0.05)from the beginning of the time of fermentation up to day 4 but reduced (P<0.05) beyond this period of fermentation. This observation may be as a result of the cooking effect before fermentation of the SBSM which leached out the water soluble vitamins. The activities of microorganisms responsible for the fermentation may have also contributed in decrease in the vitamins concentration as they may have been used up for their own metabolism.

Table 4: Effects of fermentation duration on vitamins composition of SBSM

Parameters	T1	T2	T3	T4	T5	LOS
Vitamin A (%)	93.07±0.25^{a}	67.35±0.65^{ab}	92.35±1.40^{a}	43.56±3.29^{b}	45.53±3.33^{b}	*
Vitamin B_6 (%)	3.39±0.04^{a}	2.24±1.65^{ab}	3.38±0.18^{a}	1.15±0.17^{b}	1.26±0.13^{b}	*
Vitamin E (%)	24.44±0.10^{a}	13.09±6.30^{ab}	24.39±0.39^{a}	1.68±0.34^{b}	1.85±0.10^{b}	*

LOS= Level of significance, a,b= means on the same row bearing different superscripts differ significantly *=Significant at 5% (P<0.05).

Effect of fermentation duration on amino acid composition of SBSM

The effect of fermentation duration on some amino acid composition of SBSM is presented in Table 5. As in the case of vitamins, all the amino acids analyzed; lysine, methionine and tryptophan were also improved (P<0.05) from the beginning of the fermentation to day 4 but reduced (P<0.05) as the days of fermentation proceeded beyond day 4.

Table 5: Effects of fermentation duration on amino acid composition of SBSM

Parameters	T1	T2	T3	T4	T5	LOS
Lysine (%)	1.87±0.04^{a}	1.08±0.91^{ab}	1.84±0.07^{a}	0.42±0.01^{b}	0.49±0.07^{b}	*
Methionine (%)	0.67±0.07^{a}	0.32±0.27^{b}	0.65±0.04^{a}	0.10±0.02^{b}	0.18±0.04^{b}	*
Tryptophan (%)	0.61±0.06^{a}	0.29±0.30^{ab}	0.57±0.06^{a}	0.05±0.01^{b}	0.15±0.05^{b}	*

LOS= Level of significance, a,b= means on the same row bearing different superscripts differ significantly, *=Significant at 5% (P<0.05).

Conclusion and Recommendation

Monogastric animal farmers can ferment SBSM for at most 4 days and conveniently feed their animals as a replacement for conventional energy source without affecting the growth performance of the animals. Further research especially in feeding trial is however advocated to confirm the suitability of this ingredient in question.

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