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Evaluation of the Efficiency of Different Processing Methods in Improving the Potential of Baobab Seeds in Fish Diets

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Abstract

The influence of different processing techniques on the chemical composition of baobab seed (*Adansonia digitata*) meal was investigated. Baobab seeds were subjected to four processing methods: autoclaving (0.15MPa for 30mins), toasting (150°C for 30 mins) and soaking (72 hours) in water and pulp. The seeds were milled and sieved. The proximate composition; amino acids profile; the mineral content and anti-nutritional composition were determined using standard methods. The crude protein content of processed meals ranged from 22.84±0.13 to 26.42±0.13%. Amino acids of processed seeds were significantly ($p<0.05$) the same as raw. The ranges of mineral in the processed meals are; calcium (5.71±0.00-7.61±0.06%); potassium (3.29±0.01-3.65±0.00%); manganese (0.0022±0.00-0.0283±0.35%) and these ranges were all higher than the values recorded in raw sample. Saponins (61.67±2.89-120.00±10.00 mg/100g) and oxalates (171.67±10.41-231.67±10.41 mg/100g) concentrations were lower in processed, compared to raw seed meal. The result of this study reveals the potentials of processed baobab meals as a replacement for soybean meal in fish feed.

Keywords:
Baobab, Feed ingredients, Fish feed, Processing methods, Soybean

Introduction

Fish meal, despite being the highest quality source of protein for fish feed, must be used more sparingly to improve profitability and sustainability of aquaculture (Falaye *et al.*, 2011). Several sources of plant proteins have been evaluated as partial or complete replacements for fish meal in fish diets. Soybeans protein products are good substitutes for animal products because of their complete protein profile that is essentially identical to the protein of other legume seeds and pulses (Mambrini *et al.*, 1999). However, wider utilization and availability of soybean for fish feed is limited by increasing demand for human consumption and by other animal feed industries (Fagbenro *et al.*, 2013). This has hindered the expansion and profitability of aquaculture enterprise in many developing countries, hence there is need to look for cheaper alternative protein source for the development of low-cost fish feed that can replace this conventional feedstuff without reducing the nutritional quality of the diets (Jimoh *et al.*, 2014). Baobab is widespread in Africa and its seed is one of the lesser-known, ignored and underexploited seeds with high protein and caloric content (Yusuf *et al.*, 2008). Some anti-nutritional factors have also been reported in baobab seed (Osman, 2004). One of the ways to exploit the full potential of non-conventional seeds as fish feed is to explore the potential of processing methods to reduce the toxic substances and increase the nutritional composition of the seed meal. Processing has been reported to eliminate a number of anti-nutritional factors present in the baobab seeds (Ezeagu, 2005 cited in De Caluwe *et al.*, 2009). Processing methods may also reduce the nutrient and minerals present in baobab

seed meal. This can be ascertained by determining the amino acid, mineral, and proximate composition of the meal. As a way of evaluating the potential of baobab seed to possibly replace soyabean meal in fish feed, the efficiency of four processing methods, such as soaking, autoclaving and roasting on the changes in composition of baobab seed meal was assessed in this study.

Materials and Methods

Collection and processing of baobab seeds

Baobab fruits were collected from the vicinity of the University of Ibadan, Oyo State, Nigeria. Baobab seeds were removed from baobab pods, sorted, washed and dried to attain a constant weight. The seeds were milled and sieved to obtain raw baobab seed meal (RBSM). The remaining baobab seed meals were processed as follows:

Autoclaving: Washed and dried baobab seeds were autoclaved at 0.15 MPa for 30 minutes and dried in an oven at a temperature of 70°C for 3 hours (modified method of Falaye *et al.*, 2014). The seeds were milled and sieved to produce autoclaved baobab seed meal, ABSM.

Toasting: Washed and dried baobab seeds were placed in a tray and put in an oven until the temperature reached 150° C for 30 minutes in line with the procedure used by Olaitan *et al.*, (2014). The meal produced was designated as toasted baobab seed meal, TBSM.

Soaking in water: Dried seeds were soaked in water (1:3 kg/litres) for 72 hours, sundried and roasted at 70 °C for 30 minutes (modified method of Sola-Ojo *et al.*, 2013). Its meal was designated as soaked in water baobab seed meal, SWBM.

Soaking in pulp: Part of the seeds (with pulp) were soaked in water (1:3 kg/litres) for 72 hours as suggested by Sola-Ojo *et al.* (2013), sundried and roasted at 70°C for 30 mins. The meal produced was designated as soaked in pulp baobab seed meal, SPBM.

Chemical Analysis of Meals

The percentage of the crude protein, crude fibre, moisture content, dry matter, ash content, fat content and nitrogen free extract in the differently processed baobab meals were determined by using the methods described by AOAC (2005).

The concentration of some selected minerals (Na, K, P, Fe, Zn, Co, Mg, Ca, Zn) were determined using atomic absorption spectrophotometer (AAS model: Perkin Elmer (R) 2380, USA 1976) according to AOAC (2005) method.

Amino acids compositions were determined using ion chromatography in an Amino Acid Analyser with a procedure that complies with the requirement of AOAC (1995).

Phytate in the sample was determined using the bipyrimidine colorimeter method described by Onwuka (2005). Oxalate was also determined by the method described by Onwuka (2005). The tannin content of the sample was determined by Folin-Denis colorimetric method (Harborne, 1998). Saponin was evaluated by the double solvent extraction gravimetric method (Harborne, 1998).

Statistical Analysis

Data obtained were subjected to one-way analysis of variance (ANOVA) using statistical software SPSS (22.0) and the means were separated by using Duncan new multiple range test at 5% level of probability.

Results

The moisture, crude protein, crude fat, crude fibre and ash contents of all the processed meals were significantly different P<0.05 (Table 1). SWBM had the highest moisture content 7.93±0.01%, while TSBM recorded the lowest moisture content 6.84±0.05%. The highest crude protein 26.42±0.13% was recorded in ATBM, while the lowest, 22.84±0.13% was recorded in TSBM. Crude fat ranged from 19.00±0.15% in TSBM to 21.23±0.06% in ATBM, while the crude fibre ranged from 11.80±0.03% in SWBM to 17.60±0.03% in SPBM. The highest crude ash was recorded in SWBM 7.27±0.025%, while the significantly lowest value was recorded in SPBM, 6.49±0.01%. The highest nitrogen free extract 29.98±0.11% was recorded in TSBM while the lowest was recorded in SPBM 23.60±0.19%.

Table 1: Proximate compositions of differently processed baobab seed meals and typical values of soyabean meal

Parameters %	RSBM	TSBM	ATBM	SPBM	SWBM	*SBM
Moisture content	7.14±0.01^{b}	6.84±0.05^{a}	7.41±0.02^{c}	7.56±0.02^{d}	7.93±0.01^{e}	6.31
Crude protein	23.13±0.12^{b}	22.84±0.13^{a}	26.42±0.13^{d}	24.45±0.13^{c}	24.59±0.1^{c}	37.51
Crude fat	19.22±0.03^{b}	19.00±0.15^{a}	21.23±0.06^{e}	20.31±0.01^{d}	19.89±0.0^{c}	20.45
Crude fibre	14.79±0.02^{c}	14.79±0.02^{c}	12.00±0.02^{b}	17.60±0.03^{d}	11.80±0.0^{a}	2.27
Ash	6.90±0.01^{c}	6.55±0.12^{b}	6.88±0.01^{c}	6.49±0.01^{a}	7.27±0.02^{d}	5.67
Nitrogen Free Extract	28.82±0.07^{d}	29.98±0.11^{e}	26.05±0.03^{b}	23.60±0.16^{a}	28.52±0.12^{c}	31.33

Values with different superscripts were significantly different ($p \leq 0.05$)
RSBM: Raw Baobab Seed Meal
ATBM: Autoclaved Baobab Seed Meal
SWBM: Soaked in Water Baobab Seed Meal
*SBM: Soyabean Meal (Adapted from FAO, 1997)
TSBM: Toasted Baobab Seed Meal
SPBM: Soaked in Pulp Baobab Seed Meal

The highest total phosphorus was recorded in TBSM, 0.72±0.00% while the lowest was recorded in SPBM, 0.48±0.001% (Table 2). The value recorded for calcium ranged from 4.36±0.00% in RBSM to 7.61±0.06% recorded in SWBM. The highest magnesium was recorded in ATBM, 2.01±0.00% while the lowest was recorded in SWBM. SPBM recorded the highest potassium (3.65±0.00%). The sodium recorded ranged from 0.33±0.00% in TBSM to 4.43% in SWBM (table 2).

SPBM recorded the highest manganese, iron and copper of 283.25±0.35mg/kg, 2292.50±3.54mg/kg and 21.28±0.04mg/kg respectively (Table 3), and RBSM recorded the lowest manganese of 20.48±0.04mg/kg; TBSM recorded lowest values of iron and copper; 1205±0.00mg/kg and 17.93±0.00mg/kg respectively. ATBM recorded the highest zinc, 22.43±0.04mg/kg, while the lowest value of zinc, 18.53±0.00mg/kg was recorded in SWBM.

All the amino acids analysed for raw and processed baobab seed were not significantly different at p<0.05 (Table 3). The values reported for cystine, lysine, threonine, arginine, isoleucine, leucine, histidine, phenylalanine,serine, proline, alanine, aspartic acid , and glutamic acid in soyabean were higher than those recorded for processed baobab seed meal (Table 4). The value of methione, cystine and lysine recorded for processed baobab seed meals were lower than the required level for catfish.

Table 2: Macro mineral composition of differently processed baobab seed meals and typical values of soyabean meal

Parameters %	RSBM	TSBM	ATBM	SPBM	SWBM	*SBM
Total Phosphorus	0.530 ± 0.00^{b}	0.72 ± 0.00^{e}	0.69 ± 0.00^{d}	0.48 ± 0.00^{a}	0.58 ± 0.00^{c}	0.66
Calcium	4.36 ± 0.00^{a}	6.21 ± 0.00^{c}	6.24 ± 0.00^{c}	5.71 ± 0.00^{b}	7.61 ± 0.06^{d}	0.30
Magnesium	1.82 ± 0.00^{b}	2.39 ± 0.003^{d}	2.67 ± 0.00^{e}	2.01 ± 0.00^{c}	0.76 ± 0.00^{a}	0.28
Potassium	3.06 ± 0.00^{a}	3.36 ± 0.0^{c}	3.38 ± 0.00^{d}	3.65 ± 0.00^{e}	3.29 ± 0.01^{b}	2.03
Sodium	$1.13+0.01^{c}$	$0.33+0.00^{a}$	$0.44+0.00^{b}$	$0.36+0.00^{a}$	$4.43+0.00^{d}$	0.13

Values with different superscripts were significantly different ($p \leq 0.05$)
TSBM: Toasted Baobab Seed Meal
SPBM: Soaked in Pulp Baobab Seed Meal

*SBM: Soyabean Meal (Adapted from Fitzsimmons *et al.*, 2015)
RSBM: Raw Baobab Seed Meal
ATBM: Autoclaved Baobab Seed Meal
SWBM: Soaked in Water Baobab Seed Meal

Table 3: Micro mineral composition of differently processed baobab seed meals and typical values of soyabean meal

Indices mg/kg	RSBM	TSBM	ATBM	SPBM	SWBM	*SBM
Manganese	20.48 ± 0.04^{a}	29.50 ± 0.00^{c}	45.05 ± 0.07^{d}	283.25 ± 0.35^{e}	21.50 ± 0.00^{b}	41.00
Iron	1262.50 ± 3.54^{b}	1205.00 ± 0.00^{a}	1485.00 ± 0.00^{d}	2292.50 ± 3.54^{e}	1292.50 ± 3.54^{c}	172.00
Copper	19.35 ± 0.01^{b}	17.93 ± 0.04^{a}	20.33 ± 0.04^{c}	21.28 ± 0.04^{e}	21.03 ± 0.04^{d}	15.00
Zinc	$19.95+0.00^{b}$	$20.12+0.04^{c}$	$22.43+0.04^{e}$	$21.88+0.04^{d}$	$18.53+0.04^{a}$	48.00

Values with different superscripts are significantly different ($p \leq 0.05$)
TSBM: Toasted Baobab Seed Meal
SPBM: Soaked in Pulp Baobab Seed Meal

*SBM: Soyabean Meal (Adapted from FAO, 1997)
RSBM: Raw Baobab Seed Meal
ATBM: Autoclaved Baobab Seed Meal
SWBM: Soaked in Water Baobab Seed Meal

The saponins, tannins, oxalates and phytates level recorded for the processed baobab seed meal were significantly different $p<0.05$ (Table 4). The highest saponins, 120.00 ± 5.00mg/100g and 120.00 ± 10.00mg/100g were recorded in SWBM and SPBM while the lowest, 61.67 ± 2.89mg/100g was recorded in TSBM. ATBM recorded the highest tannin 278.33 ± 7.64mg/100g while RSBM recorded the lowest tannins 213.33 ± 10.41mg/100g. RSBM had the highest oxalates 276.67 ± 10.41mg/100g, while TSBM had the lowest value of 171.67 ± 10.41mg/100g. RSBM recorded the lowest phytates 41.67 ± 2.89mg/100g, while significantly highest ($p<0.05$) phytates were recorded in SPBM (160.00 ± 5.00mg/100g).

Table 4: Amino acids compositions and total amino acid of processed baobab seed meals and typical values of soyabean meal

Parameters (% in CP)	RSBM	TSBM	ATBM	SPBM	SWBM	*SBM	*Catfish requirements
Methionine	1.41	1.55	1.46	1.43	1.37	1.10	*2.3
Cystine	1.75	1.77	1.76	1.77	1.75	2.30	*2.9-4.0
Lysine	4.79	4.89	4.78	4.76	4.68	6.75	*5.1-6.8
Threonine	2.89	3.04	2.90	2.82	2.80	4.10	2.0-2.2
Arginine	10.41	10.92	10.71	10.31	10.18	7.98	4.3
Isoleucine	3.43	3.62	3.49	3.37	3.33	4.69	2.6
Leucine	6.32	6.65	6.38	6.19	6.16	8.11	3.5
Valine	4.69	4.97	4.75	4.47	4.54	5.07	3.0
Histidine	2.24	2.35	2.28	2.21	2.18	2.72	1.5
Phenyl alanine	4.46	4.72	4.55	4.42	4.37	5.34	4.5-5.0
Glycine	4.48	4.76	4.57	4.41	4.39	4.69	
Serine	4.84	5.08	4.91	4.81	4.74	5.38	
Proline	3.42	3.69	3.53	3.32	3.27	6.82	
Alanine	4.19	4.41	4.21	4.09	4.09	4.43	
Aspartic acid	8.55	9.08	8.73	8.41	8.36	12.45	
Glutamic acid	21.65	22.90	22.12	21.59	21.22	19.98	
Total amino acids (%)	89.53	94.40	91.12	88.46	87.42	91.90	

Valucs without superscripts arc not significantly different ($p \leq 0.05$)
*Adapted sources: Jurgen, (1998); Wilson and Robinson, (1982)
SBM: Soyabean Meal
RSBM: Raw Baobab Seed Meal
TSBM: Toasted Baobab Seed Meal
ATBM: Autoclaved Baobab Seed Meal
SPBM: Soaked in Pulp Baobab Seed Meal
SWBM: Soaked in Water Baobab Seed Meal

Table 5: Anti-nutritional composition in differently processed baobab seed meals and typical values of soyabean meal

Parameters mg/100g	RBSM	TSBM	ATBM	SPBM	SWBM	*SBM
Saponins	131.67 ± 7.64^{c}	61.67 ± 2.89^{a}	105.00 ± 5.00^{b}	120.00 ± 10.00^{c}	120.00 ± 5.00^{c}	600
Tannins	213.33 ± 10.41^{a}	250.00 ± 13.23^{b}	278.33 ± 7.64^{c}	216.67 ± 10.41^{a}	228.33 ± 7.64^{a}	29.3
Oxalates	276.67 ± 10.41^{c}	171.67 ± 10.41^{a}	216.67 ± 7.64^{b}	228.33 ± 7.64^{b}	231.67 ± 10.41^{b}	NM
Phytates	41.67 ± 2.89^{a}	111.67 ± 7.64^{c}	131.67 ± 2.89^{d}	160.00 ± 5.00^{e}	51.67 ± 5.77^{b}	212

*SBM: Soyabean Meal (Fitzsimmons *et al.*, (2015) and El-Shemy, (2000)
Values with different superscripts are significantly different ($p \leq 0.05$)
RSBM: Raw Baobab Seed Meal
TSBM: Toasted Baobab Seed Meal
ATBM: Autoclaved Baobab Seed Meal
SPBM: Soaked in Pulp Baobab Seed Meal
SWBM: Soaked in Water Baobab Seed Meal
NM: Not mentioned

Discussion

Processing improved the crude protein of ATBM, SPBM and SWBM. The reduction in crude protein, crude fat, moisture content and ash of TSBM might be due to the temperature (150°C) used in toasting the seeds. The temperature might have denatured the crude protein. The crude protein content of the processed baobab seed meal recorded in this study was lower than the value reported by Sola-Ojo, *et. al.* (2011); Yusuf *et al.*, (2008) and higher than the value of 16.6% reported by Ezeagu (2005), 18.4% reported by Anene *et.al.* (2012). Discrepancies in crude protein content might be because of the difference in fibre level in the meal, baobab seed meal with reduced fibre level have high crude protein content. It could also be due to variability in nutrients content of baobab seeds as a result of soil composition around baobab tree (Parkouda *et. al.*, 2012). Though, the crude protein reported in

soyabean meal (Table 1) is higher than those recorded for processed baobab seeds, baobab seed meal may partially replace soyabean meal in fish feed because, in virtually all cases, the crude protein content of the processed baobab seed meal were above 60% of the crude protein in soyabean meal.

Processing increased the mineral composition of baobab seed meal. The reduction in value of sodium, iron and copper recorded in TSBM compared to the raw seeds could be attributed to the temperature used in its processing compared to others (Table 2). SPBM recorded highest potassium, iron, manganese and copper. The high value of manganese and iron reported in SPBM might be due to the high level of the minerals in baobab pulp. However, the values of macro and micro mineral compositions recorded in this study were higher than the value of minerals in fermented baobab seed meal that was reported by Adedayo and Sani (2015) to meet the level required for human and animal feed. This could be as a result of the difference in the processing methods used. The calcium, magnesium and potassium values recorded in this study were above the values reported for soyabean (Table 3).

The amino acids parameters analysed for raw and processed baobab seed were not significantly different $P<0.05$. The values recorded for most of the amino acids analysed in raw and processed baobab seed meal were slightly lower than those reported in soyabean (Table 4). The methione, cystine and lysine contents in the baobab seed meal reported in this study were lower than the requirement for African catfish. Hence, combination of other protein sources to complement the missing amino acids in baobab seed meal acids when formulating fish feed is desirable. Mukhopadhyay and Ray (1999) reported that sesame seed meal has low content of lysine but supplementing sesame diets with lysine improved growth and feed utilization in *Labeo rohita.*

Low saponins and oxalates levels were recorded in TSBM while the SPBM and SWBM recorded a lower tannin level compared to ATBM and TSBM (Table 5). The heat used in autoclaving and toasting could have contributed to the increase in tannin level and reduction in saponin and oxalates. The reduction in phytate level of SWBM was similar to the findings of Vijayakumari *et al.*(1996), who reported that soaking *Mucuna pruriens* seeds in distilled water is more effective in reducing phytic acid contents than soaking in sodium bicarbonate solution.

The tannin, phytate and saponin contents in the raw and processed seeds reported in this study were lower than the values reported by Olaitan *et al.* (2014) who reported 0.50±0.10% phytate, 2.27±0.31% tannin and 3.26±0.53% saponin in roasted baobab seed coffee-like beverage. This may be due to difference in the processing techniques that were used in the studies, that is, removal of seed coat by sieving that was done during processing of seed meal in this study. The phytate and saponin levels obtained in raw and processed baobab meals were lower than those reported for soyabean meal, 212 and 600mg/100g respectively (El-Shemy *et al.*, 2000 and Fitzsimmons *et al.*, 2015). The saponin levels (61.67mg/100g-120.00mg/100g) for this study is also within the established tolerance limits of below 1g/kg of diet in commonly cultured fish (Francis *et al.*, 2001). Phytic acid (41.67mg/100g-160mg/100g) is within the recommended tolerable limits of below 5g/kg in fish feeds (Francis *et al.*, 2001) while tannin level (213.33±10.41mg/100g- 278.33±7.64mg/100g) corresponds with the level acceptable in foods which is 2 g/100 g (Munro and Bassir, 1969).

Further studies need to be carried out to know the seed meal that would be best acceptable and digestible by fish, and also to determine the best replacement level of soyabean meal by the processed baobab seed meal in fish diet.

Conclusion

Toasting reduced the saponins and oxalates level in baobab seed as well as its crude protein, crude fat, ash, sodium, iron content. Autoclaving, soaking in water and pulp not only reduced the saponins and

oxalate levels but also increased crude protein and mineral composition in baobab seed meal. Hence, baobab seed meals prepared using these three processing methods, have better potential of being used as replacement for soyabean meal in fish diets.

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