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Effects of Toasting on Nutritional Value of Mesquite (Prosopis africana) Seeds and Its Utilization by Oreochromis niloticus Fingerlings

Shina Al-habeeb Aroyehun*[1] Wilfred Olusegun Alegbeleye[1] Olubunmi Temilade Agbebi[1]
Adeyemi Mustafa Bamgbose[2]
1.Department of Aquaculture and Fisheries Management, Federal University of Agriculture, P.M.B 2240, Abeokuta, Nigeria
2.Department of animal nutrition, Federal University of Agriculture, P.M.B 2240, Abeokuta, Nigeria

Abstract
Nutritive value of mesquite (*Prosopis african*) seeds subjected to toasting processing method in the diet of *Oreochromis niloticus* fingerlings was studied in an 84-day feeding trials. One hundred and twenty all male fingerlings of *O. niloticus* (5.53 ± 0.01 g) were stocked in triplicate and 4 iso-nitrogenous diets (35 % crude protein) were formulated using the toasted mesquite seed at 0 %, 15 %, 30 % and 45 % inclusion levels to replace soybean meal (SBM) in a completely randomized design (CRD). Proximate composition of the seed was significant ($P < 0.05$) on crude lipid, fiber and mineral content of mesquite seed. Essential amino acids profile were differently affected. The anti-nutritional factor tannin and phyate were slightly reduced. The highest weight gain (5.32 g), specific growth rate (1.77 %day^{-1}), feed conversion efficiency (0.71) protein efficiency ratio (2.02 %) and economic conversion ratio ($0.91 /kg) were observed in group fed diet I while diet 3 gave the least. Carcass proximate analysis showed high value for crude protein and ash content. Toasted mesquite seed meal could be exploited in the on-farm production of tilapia diet at 15 % inclusion level.
Keywords: Mesquite seeds, toasting method, amino acids, nutrient utilization and *Oreochromis niloticus*.
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1. Introduction

Oreochromis niloticus has become the fifty most cultured fish in world with production value of 3, 670 260 tonnes behind Carp of which Nigeria is one of the largest producers in sub-Saharan Africa Atanda and Fagbenro (2017). However, tilapia production has been less outstanding owning to some of the major constraints deterring the development such as Low input technology (extensive culture system), Precocious breeding and high cost of feed.

Although, there has been deliberate effort either by the private sector or the government to improving the input technology and as well as breakthrough toward checking the precocious breeding of tilapia through genetically modified parent stock and administration of Methyl-testosterone (MT) feed, availability of cost effective and highly quality feed still remains a major constraint to tilapia production (Ajani *et al*. 2016). This is because of the rising cost of common protein ingredients such as fish meal and soybean.

Soybean meal is the most extensively used plant protein source in livestock diets as it has a high crude protein content and a well-balanced essential amino acids profile (Alegbeleye *et al*. 2012). However, inclusion of soybean in practical fish rations is constrained by its competitive use as a dietary protein source for human, livestock nutrition, use in bio-fuel, decline in national production and increasing costs have encouraged the search for a substitute (Jimoh *et al*. 2015). Hence, it is important to evaluate the nutritive value of other inexpensive under-utilized plant protein sources that would replace soybean meal such as mesquite seed.

Prosopis africana seed is among these abundant plants. It can be found growing wild in Nigeria and other parts of West Africa (Orwa *et al*. 2009). The fruits occur as pods which are dark brown cylindrical thick and hard shiny up to 15 x 3 cm with woody walls compartmented; about 10 loose rattling seeds per pod (Orwa *et al*. 2009). Its common names include African mesquite, Iron tree, while its local Nigerian names are Kiriya (Hausa), Ayan (Yoruba) and Ubwa (Ibo) (Ogunshe *et al*. 2007). This study therefore, assess the effects toasting on the nutritive value of mesquite seed and to evaluate performance of the toasted seed meals in the diet of *O. niloticus* fingerlings.

2. Materials and methods

2.1 Feed procurement, processing and analysis

Mature mesquite seeds were purchased from a local market, in Gboko, Benue State, Nigeria. The other ingredients: soybean meal, groundnut cake, maize, fishmeal, vitamin and mineral premixes were obtained from a reputable livestock feed store at Fajol area, Abeokuta, Nigeria.

The seeds were toasted using a local heating system of stove at temperature between 80 °C and 120 °C for

15 minutes (Sotolu and Faturoti 2008). The toasted seed coats were removed by cracking the seeds and winnowing prior to milling by food blender (3D model) to produce toasted mesquite seed meal (TMS).

Toasted and raw seed samples were analysed for proximate composition, amino acid profile and anti-nutritional factor. The proximate composition was determined using methods described by Association of Official Analytical Chemists (AOAC 2005) while the amino acid profile was determined using the method described by Benitez (1989). The anti-nutrient analysis such as phytate and tannin were determined by the method of Graham (1992) and Wheeler and Ferrel (1971) respectively. The proximate composition of the fish carcass before and after the feeding trial were also determined according to AOAC (2005).

2.2 Diet formulation

Four iso-nitrogenous (35 % crude protein) and iso-caloric diets were formulated, with toasted mesquite seeds each replacing soybean meal at three levels (15 %, 30 % and 45 %) while the control diet was without mesquite seed meal, this is shown in table 3. Chromic oxide was used at 0.5 % in all the experimental diets as an inert marker to determine the digestibility coefficient of nutrients in the diets. The ingredients were properly sieved to remove chaff and ensure homogenous size profile, mixed and pelleted through a 2 mm die using hand pelletizer (unbranded). The pellets were air dried and packed in properly labeled cellophane bags for use.

2.3 Experimental system and fish

The feeding trials were conducted in the fish hatchery of Aquaculture and Fisheries Department, College of Environmental Resources Management, Federal University of Agriculture Abeokuta, Nigeria.

One hundred and twenty all male fingerlings of *O. niloticus* (5.53 ± 0.01 g) were obtained from a reputable farm, Lagos state. They were acclimated to experimental condition for seven days in a circular (2000 L) glass fibre tank prior to the feeding trial. Equal twelve plastic 50 L tanks, dimension (49 x 33.5 x 33.5 cm^3) and water filled to 75 % were randomly allocated to the four treatments. Ten fish per tank each were replicated thrice in a completely randomized design (CRD). The fish in each tank were batch weighed with the use of a sensitive weighing balance (METER TOLEDO FB602) to ensure uniformity in size in each tank and were covered with synthetic net to prevent fish from jumping out.

2.4 Fish maintenance and sample collection

Experimental fish in each tank were fed the experimental diet for period of 12 weeks at the rate of 3 % body weight per day, shared between morning (9.00 am) and evening (4.00 pm). The fish were starved for 24 hrs before the commencement of feeding trial. Fish were batch weighed weekly with a sensitive weighing balance (METER TOLEDO FB602) and the rations were adjusted according to weight gain. Water temperature, pH and dissolved oxygen were monitored in the course of the experiment weekly using standard methods. After feeding the fish for twelve weeks, Growth and nutrient utilization was evaluated on experimental fish according to Sotolu and Faturoti (2008). Fish faeces were collected daily for 2 weeks to the end of the experiment. One hour after the feeding, any feed and faeces present in the tanks was removed while fresh faeces produced by the fish after this period and before the next feeding were siphoned immediately in replicates to minimize leaching of nutrients into water. The collected faeces were filtered onto filter papers and dried. The faecal samples from each replicate tank were pooled according to treatment and stored in tagged cellophane bags in a freezer at 10 °C. Based on chromic oxide content of the diet, and nutrient content of the diet and faeces, apparent digestibility coefficients (ADCs) for feed protein were determined using the acid digestion method of Furukawa and Tsukahara (1966). The ADCs were calculated with the following formula:

$$\text{ADC (\%)} = 100 - \left[100 \times \left(\frac{\%\ Cr_2O_3 \text{ in diet}}{\%\ Cr_2O_3 \text{ in faeces}} \times \frac{\%\ \text{nutrient in faeces}}{\%\ \text{nutrient in diet}}\right)\right]$$

Based on the current market price of the ingredients in local market at the time of the study and the quantity that was required to make the different diets, the cost for 1 kg of each diet was calculated. Economic evaluation in terms of economic conversion ratio (ECR) and economic profit index (EPI) of substituting toasted mesquite seed meal for soybean meal in the diet of *O. niloticus* were calculated according to Moutinho *et al.* (2017).

$$\text{ECR (₦/kg)} = \text{FCR} \times \text{diet price (₦/kg)}$$

EPI (₦) = [Weight gain (kg) × selling price (₦/kg)] - [weight gain (kg) × diet Price (₦/kg)]

2.5 Statistical analysis

Results were analyzed using SPSS (Statistical Package Computer Software, 1988 version, Chicago Illinois, USA). Statistical analysis of data was done by one-way analysis of variance (ANOVA). Mean differences between treatments was tested for significance ($P < 0.05$) using Duncan's Multiple Range.

3. Results

There were significant differences ($P < 0.05$) in crude lipids, fibre and mineral contents in the proximate composition (Table 1). Lower values were recorded for both Tannin and Phyates in toasted seeds. Higher values were obtained in essential amino acid (EAA) of toasted compare to toasted Soybean. Lower values were recorded for methionine and tryptophan of toasted compared to raw seeds (Table 2).

No pathological signs were observed during the trial, and mortality was very low and unaffected ($P < 0.05$) by the dietary treatments (Table 4). Final body weight, weight gain and specific growth rate of fish fed diet 3 were significantly difference ($P < 0.05$) from those fed the control diet (Table 4). However, those fed diet 1 and 2 were similar with those fed control diet ($P > 0.05$). Likewise, similar ($P > 0.05$) feed conversion ratio and protein productivity ratio were observed for control and diet 1 groups. Despite the highest voluntary feed intake, fish fed diet 3 obtained the lowest ($P < 0.05$) growth performance and feed efficiency. At the end of the trial, carcass composition were significantly affected as showed in Table 5. The feed cost of producing one kilogram of fish expressed as economic conversion ratio (ECR) for diet 1 was significantly ($P < 0.05$) lower than the control diet and all other diets (Table 6).

Table 1: Proximate composition and anti-nutritional factor of mesquite seeds (%)

Parameters	Toasted	Raw
Moisture	13.55±0.35^a	14.80±0.40^a
Crude protein	37.89±1.58^a	35.10±1.07^a
Crude lipid	03.46±0.05^b	04.02±0.01^a
Ash	04.25±0.06^a	04.00±0.15^b
Crude fibre	05.41±0.25^b	07.79±0.07^a
NFE*	35.44±1.67^b	34.29±1.27^b
Calcium	2.42±0.10^a	2.11±0.07^b
Phosphorus	2.55±0.13^a	2.31±0.04^a
Tannin	2.4	2.8
Phyate	3.0	3.6

Means on the same row with the different superscript are significantly different $P < 0.05$ Key NFE*: nitrogen free extract.

Table 2: Amino acids Profile (g / 100 g protein) of toasted Mesquite Seeds

Amino acid	Toasted	Raw	Toast Soybean*
Arginine	5.76	5.59	4.48
Histidine	2.04	2.24	3.00
Isoleucine	2.95	3.21	2.32
Leucine	7.70	7.29	6.00
Lysine	5.04	4.56	3.60
Methionine	1.76	1.82	0.88
Phenylalanine	3.81	3.99	3.06
Threonine	3.55	3.38	2.80
Tryptophan	0.60	1.00	-
Valine	3.68	3.67	2.85
Non-essential			
Tyrosine	3.61	3.10	2.63
Proline	3.25	3.25	3.08
Cystine	0.60	0.85	0.70
Alanine	4.85	4.17	3.04
Glutamic acid	12.72	12.26	14.94
Glycine	5.03	4.51	3.35
Serine	2.48	3.46	1.90
Aspartic acid	10.62	9.02	10.49

*Ari *et al*. (2012)

Table 3: Formulation and proximate composition of the experimental diets

	Control	Diet 1	Diet 2	Diet 3
Ingredients (%)				
Maize	27.91	27.41	27.41	27.41
Fish meal	16.02	16.15	16.15	16.15
Groundnut cake	16.02	16.15	16.15	16.15
Soybean Meal	32.05	27.45	22.60	17.76
Toasted MSM[1]	-	4.84	9.68	14.53
Vegetable oil	5	5	5	5
Vit/ Min premix	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5
Starch	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25
Dicalciumphosphate	0.5	0.5	0.5	0.5
Chromic oxide	0.5	0.5	0.5	0.5
Proximate analysis (%)				
Moisture	9.29	9.57	9.39	9.22
Crude lipid	10.88	11.00	10.49	10.66
Ash	10.68	10.23	10.37	10.29
Crude protein	36.01	35.18	35.52	35.79
Crude fibre	4.08	4.44	5.42	5.00
Nitrogen free extract	29.08	29.58	28.82	29.05
Gross energy(KJg^{-1})[2]	17.42	17.35	17.11	17.27

[1]Mesquite seed meal, [2]Calculated using the factors: carbohydrates, 4.1 kcal g^{-1}; protein, 5.5 kcal g^{-1} and lipids, 9.1 kcal g^{-1} (New 1987) and transformed to kJ using the factor 4.184.

Table 4: Growth performance and nutrient utilization of *O. niloticus* fed experimental diets.

Parameters	Control	Diet 1	Diet 2	Diet 3
Initial weight (g)	5.53 ± 0.02^{a}	5.54 ± 0.10^{a}	5.53 ± 0.01^{a}	5.52 ± 0.01^{a}
Final weight (g)	10.60 ± 0.70^{a}	10.86 ± 0.40^{a}	10.43 ± 0.34^{a}	10.31 ± 0.08^{b}
Weight gain (g)	5.08 ± 0.60^{a}	5.32 ± 0.38^{a}	4.89 ± 0.34^{a}	4.78 ± 0.09^{b}
Survival rate (%)	100 ± 0.00^{a}	96.67 ± 5.76^{a}	100 ± 0.00^{a}	100 ± 0.00^{a}
Feed intake (g)	7.35 ± 0.26^{c}	7.51 ± 0.16^{c}	7.65 ± 0.38^{ab}	8.08 ± 0.38^{a}
Specific growth rate (% day^{-1})	1.74 ± 0.00^{a}	1.77 ± 0.07^{a}	1.70 ± 0.07^{a}	1.66 ± 0.05^{b}
Feed conversion ratio	1.45 ± 0.04^{b}	1.42 ± 0.09^{b}	1.56 ± 0.17^{ab}	1.69 ± 0.09^{a}
Feed Efficiency ratio	0.69 ± 0.02^{a}	0.71 ± 0.04^{a}	0.64 ± 0.07^{bc}	0.59 ± 0.04^{b}
Protein Efficiency ratio (%)	1.97 ± 0.05^{a}	2.02 ± 0.12^{a}	1.82 ± 0.20^{bc}	1.69 ± 0.11^{c}
Protein productivity value (%)	0.66 ± 0.03^{a}	0.64 ± 0.02^{a}	0.47 ± 0.03^{b}	0.18 ± 0.02^{c}
Apparent dry Matter digestibility (%)	$77.88\pm.03^{ab}$	78.58 ± 1.05^{ab}	$78.86\pm.25^{a}$	78.46 ± 1.30^{ab}
Apparent protein digestibility (%)	83.23 ± 0.31^{a}	$80.27\pm.17^{b}$	$79.40\pm.51^{bc}$	$78.13\pm.15^{c}$

Means on the same column with the different superscript are significantly different ($P < 0.05$)

Table 5: Proximate carcass composition (%) of *O. niloticus* fingerlings fed the experimental diets.

Parameters	Initial	Control	Diet 1	Diet 2	Diet 3
Moisture	$76.23\pm.34^{a}$	$73.56\pm.96^{a}$	$75.35\pm.20^{a}$	73.57 ± 1.1^{a}	$75.50\pm.45^{a}$
Protein	$52.22\pm.04^{d}$	$53.85\pm.05^{a}$	$53.90\pm.00^{a}$	53.50 ± 0.0^{c}	53.65 ± 0.0^{b}
Lipid	8.70 ± 0.25^{a}	8.39 ± 0.2^{b}	$7.22\pm.03^{d}$	$7.22\pm.03^{d}$	7.59 ± 0.08^{c}
Ash	10.53 ± 0.08^{d}	$11.22\pm.02^{c}$	$11.30\pm.02^{c}$	$11.76\pm.11^{b}$	$13.49\pm.01^{a}$

Means on the same row with the different superscripts are significantly different ($P < 0.05$)

Table 6: Economic analysis of *O. niloticus* fingerlings fed experimental diets

Parameters	Control	Diet 1	Diet 2	Diet 3
Diet price ($/Kg)	0.93	0.91	0.86	0.81
ECR ($/Kg)	1.35^{b}	1.29^{c}	1.34^{b}	1.37^{a}
EPI	0.004	0.004	0.004	0.004

Means on the same row with the different superscripts are significantly different ($P < 0.05$)

4. Discussion

The crude protein content of raw mesquite seeds (35.10 %) (Table 1) were found to be higher which is comparable to other leguminous plants such as locust bean (28.54 – 32.40 %) Hassan and Umar, (2005), baobab seeds (20-36 %) and sunflower seeds (24.4-36.7 %) Prince *et al*. (2017). Thus this higher level of protein content is a pointer to it nutritional significance, since moderate intake of these seeds will greatly increase the total dietary protein intake of the fish. The measurable increase in crude protein of toasted mesquite seed meal compared to the raw sample thus contrast with the observations of Southgate (2000) but agreed with the observation of Doss *et al*. (2011); Olanipekun *et al*. (2015) reported that this could be due to breakdown of crude protein to amino acids. The raw sample had the highest value (7.79 %) for crude fibre and this was found to be comparable with other legumes such as Jack bean (7.37 %) (Doss *et al.* 2011). Toasting also improved the mineral content of the seed meal compared to raw sample, this disagreed with the observation of Kankengi *et al.* (2003).

The amino acid concentration in the toasted mesquite seeds with respect to Histidine (2.04 g / 100 g), Isoleucine (2.95 g / 100 g), Methionine (1.76 g / 100 g), Phenylalanine (3.81g / 100 g) and Tryptophan (0.60 g / 100 g) values were lower compared to the raw sample (Table 2). This could be traced to heating which is known to denature proteins or irreversible combination of amino acids with other nutrients (Southgate 2000).

In this study, a marked reduction in the level of phytic acid and tannin of toasted mesquite seed is similar to some previous studies where processing method was effective in reducing it (Mukhopadhyay and Ray 2001); (Alegbeleye and Olude 2009). This suggests that the observed anti-nutritional factors in toasted mesquite seeds will have no effect on the fish.

The performance of *O. niloticus* at the end of the experiment was influenced primarily by the amount of toasted mesquite seed meal in the diet. Growth and nutrient utilization were significantly high ($P < 0.05$) in the group fed diet 1 control and diet 2 in contrast to the group fed diet 3. This shows that partial (10 % -15 %) replacement of soybean with toasted mesquite meal did not compromise the fish growth. However, higher replacement level showed a significant ($P < 0.05$) reduction in growth and nutrient utilization as revealed in the group fed diet 3. Mesquite seed has been shown (Table 1) to contain high level of fiber. These are not digestible by monogastric animals, with some components having anti-nutritional effects in fish (Chou *et al*. 2004). The low growth and nutrient utilization in fish fed diet 3 could be attributed to an increase in the fiber content of the diet.

Carcass proximate analysis showed high value for crude protein and ash. The highest ash content and high crude lipid obtained in diet 3, could be due to availability of sufficient energy in the diet (Ajani *et al*. 2016). The high crude protein obtained in diet 1 which was not significantly different ($P > 0.05$) from control agreed Abdelghany (2003), who reported that diets containing soybean meal for *O. niloticus* increased body protein.

Replacement of SMB with toasted MSM appears to be economically feasible. The cost of formulating present diets for *O. niloticus* was reduced as toasted MSM levels increased and this was in consonant with previous studies where conventional feed stuff were partial replaced with meat and bone meat in diets for gilthead seabream (*Sparus aurata*) juveniles (Moutinho *et al.* 2017).

5. Conclusions

This study demonstrated that mesquite seed contains high protein value and appreciable quantity of minerals, and toasting significantly reduced ($P < 0.05$) the levels of tannins and phytates in the seed. Therefore, toasted mesquite seed meal could be exploited by the small holder farmers at 15 % inclusion level in production of fish feeds to reduce the cost of production of tilapia diets. To explore higher inclusion levels further studies on other processing methods are recommended since toasting alone seems not to be effective in removing crude fibre content.

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