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Digestibility and Nutritional Values of Differently Processed *Leucaena leucocephala* (Lam. de Wit) Seed Meals in the Diet of African Catfish (*Clarias gariepinus*)

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Abstract: High cost of fishmeal for fish feeds is a major constraint to the growth of aquaculture in Nigeria. Dearth of information on suitable alternatives to fish feed ingredients persists. Processing and digestibility potentials of *Leucaena leucocephala* seed meals (LSM) as feed ingredient were therefore investigated in *Clarias gariepinus* diets. The seeds were collected and processed by sun-drying (SD), toasting (TS), soaking in water (SW) and soaking in alkaline solution (SA). Four isonitrogenous diets {40% Crude Protein (CP)} were prepared using the processed LSMs and a 14-day digestibility study was conducted using *C.gariepinus* fingerlings. *C.gariepinus* fingerlings (average weight 5.72±0.02g) were subjected to treatments in three replicates using a Completely Randomized Design. Chemical analyses of experimental feeds and fish were conducted before and after feeding trials. Dissolved oxygen, temperature and pH were monitored and data were analysed using descriptive statistics, ANOVA and correlation. Differently processed LSMs varied generally both in their nutrient and mineral compositions. SW produced meal of highest CP (36.01%) with highest Mean Weight Gain (MWG) of 0.32g while SD had the least CP (22.75%) and the least MWG. Digestibility coefficients of protein and calorie varied significantly ($p<0.05$) among fish-fed processed LSM from 66.9 (SD) to 73.6 (SW) and 64.2 (SD) to 70.2 (SW) respectively. Fish carcass protein was only marginally different among treatments with the highest (63.34%) in SW and the least (62.11%) in TS. Survival rate was generally high in all treatments with overall mean of 95%. *Leucaena leucocephala* offers a good potential as a cheaper plant protein source in fish diet with high nutritive value. *Clarias gariepinus* was able to utilize SW-based diet better than other processed leucaena for sustainable aquaculture.

Key words: Leucaena seed meal · Processing · *Clarias gariepinus* · Digestibility · Aquaculture

INTRODUCTION

Much as fish faming has been seen as a possible saviour for the over-burdened capture fisheries with continued evolvement of new opening and exciting possibilities [1,2], lack of readily available cheap nutritive fish feed ingredients has been observed to be a major constraint to the survival of aquaculture in the competitive global food production system [2, 3].The survival of the aquaculture industry in many LIFDCs has continued to depend heavily on the importation of fishmeal and finished aqua feeds. This practice in turn impedes the realization of its aim of providing sufficient quantity of quality fish to meet the protein need of the people especially, the rural poor of Sub-Saharan Africa [4, 5]. Consequently, fish nutrition experts have considered the recruitment of other alternative protein feed ingredients necessary for fish farming. Studies have shown that vegetable protein sources have high potentials for supplying fish with their required protein need for maximum productivity after been properly processed [6] otherwise, fish are found to exhibit slower growth rates and poor performance that may result in mortality if condition persists [7, 8]. These occurrences have been traced to the presence of substances within vegetable meals that inhibit nutrition in fish species [8, 9]. These substances, called antinutritional factor have the potential of precipitating

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adverse effect on the productivity of farm livestock [10]. It was therefore recommended that vegetable meal be properly processed before use in practical fish feeding [11, 12].

Leucaena leucocephala known as "multipurpose tree" [13] due to its diverse use is one of the numerous legume grains and shrubs that are in abundance in Nigeria playing a very important role in ecological and biodiversity conservation as well as in ruminant farming in the country. *L. leucocephala* was reported capable of producing about 3-5 tonnes seeds ha^{-1} yr^{-1} [10] and high crude protein (CP) value of 28 to 45% [14]. *L. leucocephala* is known to be high in â-carotene [15] with a rich amino acid profile [16] and it has however been confirmed that it contains mimosine; a non-protein amino acid substance [15, 17, 18] which is capable of retarding growth of animal that consume it in large quantity and precipitating other forms of adverse conditions if not checked [17, 19]. [20, 21] reported an impressive yield of milk both per cow and per hectare in the tropics. The work of [22] revealed that leucaena can be used as a feed ingredient for mollies and topminnows (*Poecilia spp*.) and freshwater prawn, *Macrobrachium rosenbergii* while [23] reported it nutritional competence in raising chicken broiler. [24] found that 33 to 100% Leucaena leaf meal (LLM) as a component of supplemental feed enhanced growth of *Oreochromis niloticus* fingerlings in cages in Laguna lake whereas, [19] observed an inverse relationship between the level of mimosine in leucaena diets and survival rate of *Penaeus monodon* juveniles. This study therefore examined the nutrient potentials of processed Leucaena Seed Meals (LSM) in the diet of *Clarias gariepinus* for sustainable aquaculture production.

MATERIALS AND METHODS

Processing of *Leucaena leucocephala* Seeds into Meal: Seeds of leucaena were harvested from the leucaena pastureland of the Department of Agronomy, University of Ibadan. Matured pods were harvested with the aid of a long sickle and were collected in sacks and transported to the Department of Wildlife and Fisheries Management of the University. The pods were immediately spread on a slab for solar drying for two weeks. After sundrying, the pods were shredded to release their seeds inside a sack and all forms of impurities such as empty pods, rachis and leafleolets were removed completely. The whole pure seeds were later sundried for three days to ensure uniform dryness. The following methods were employed in processing the leucaena seeds towards the utilization of its meal by African catfish (*Clarias gariepinus*).

Toasting (TS): Leucaena seeds weighing 1 kilogram were collected into a cooking pot and toasted for 15 minutes at 80°C by which time the seeds coat have become reddish brown to ox blood colour emitting cooking aroma similar to that of coffee. The toasted seeds were then collected and milled using Thomas Wiley milling machine.

Soaking in Alkali and Sun Drying (SA): Seeds of leucaena weighing 1 kilogram were soaked in 100°C water that contained potash at $5g^{-1}$ 250g of seed according to [25] and were allowed to cool down for three days. Treated seeds were then collected by losing the water through sieve and immediately sundried for two days. The seeds were later milled using Thomas Wiley Miller.

Soaking in Water and Sun Drying (SW): Seeds of leucaena weighing 1 kilogram were soaked in cold water at 1 kilogram $seed^{-1}$ 5 litre of water for 72 h as described by [26, 27]. Treated seeds were then collected by losing the water through sieve and immediately sundried for two days. The seeds were later milled using Thomas Wiley Miller.

Sundrying (SD): One kilogram of the initially sundried leucaena seeds was collected and further sundried from morning till evening (when the sun started setting) only for a day. The seeds were then milled using Thomas Wiley Miller.

Proximate Analysis of Processed Leucaena Seeds: The proximate analysis of the processed leucaena seed meals was carried out according to Association of Official Analytical Chemists [28]. The parameters considered were Crude protein, Crude fibre, Fat, Ash, Moisture content, Nitrogen free extract (NFE) and Calorific Value.

Preparation of Experimental Diets and Proximate Analysis: Four (4) practical isonitrogenous diets {40% crude protein (CP)} were prepared by incorporating each of the processed LSM in a diet. Other ingredients use in the preparation of the feeds are fish meal, ground nut cake, soya bean meal, soya bean meal, palm oil, bone meal, oyster shell and vitamins premix. A slight variation was made in the quantity of palm oil and other additives included in the diets to accommodate 1% chromic oxide as a marker.

Each of the feed ingredients was finely ground, mixed with other ingredients and later pelleted using a local pelletizing machine. Thereafter, samples of the feeds were taken to the laboratory for proximate analysis according to [28] and the rest are allowed to air dry homogenously and later packed separately in an airtight polythene bag, labeled and stored safely for the 14-day digestibility study.

Digestibility Study: The experiment was set-up in the Postgraduate laboratory section of the Department of Wildlife and Fisheries Management University of Ibadan. A total of 25 *Clarias gariepinus* fingerlings (average weight 5.72±0.09g) were randomly distributed in plastic tanks of 70L capacity. Each treatment was distributed into triplicates on random basis and they were supplied with deep well water at a constant flow rate of approximately 2 L min^{-1} . Water quality parameters were measured at initial stage and weekly for two weeks with a combined digital (YSI) meter. Initial mean values observed were: 6.63±0.2, 5.35±0.1 mgL^{-1} and 26.75±0.4°C for pH, dissolved oxygen and temperature respectively. Fish were fed three times daily *ad libitum* at 09.000h-09.30h, 12.00h – 12.30h and 17.00 h– 17.30h for 14 days after acclimation period of 3 days.

Faeces were collected from each tank daily (8 h after feeding) by siphoning with rubber tube and were oven dried at 48°C. Faecal wastes were also collected from each treatment 8h after feeding on the last day by rectal dissection method [29, 30] from terminal 2.5cm of the intestine after anaesthetizing the fish in quinaldine (2.5ml) and the collection for each treatment done, they were then taken to the laboratory for analysis according to the method described by [30]. Fish mortalities in each tank were recorded and used to calculate survival rate for each treatment. The final proximate analysis of fish under each treatment was also done at the end of the experiment for C.P, crude fibre, Ash, lipid [28]. The entire fish population in each tank was weighed at the end of the 14-day experiment and mean weight recorded per treatment, which was later, used to calculate for growth and nutrient utilization parameters. Parameters of importance included Percent mean weight gain, Protein efficiency ratio (PER), Productive protein value (PPV), Specific growth rate (SGR), Feed conversion ratio (FCR), Nitrogen metabolism (Nm) and Digestibility coefficients of energy and protein (ADC_{energy}) and ($ADC_{protein}$).

Determination of Growth and Nutrition Utilization and Digestibility Coefficient

1. Mean weight gain (MWG) = $(W_2 – W_1)$ g

Where; W_1 = initial mean weight (g) and W_2 = final mean weight (g)

2. Specific growth rate (SGR) % =
$Log_e W_2 - Log_e W_1/T_2 – T_1 \times 100$

Where; W_2 = final weight (g) at time T_2 (end of experiment), W_1 = Initial weight (g) at time T_1 (beginning of experiment) and Log_e = Natural logarithm.

3. Percentage Weight Gain (PWG) % =
Mean Weight gain/Initial Mean Weightx 100

4. Feed Conversion Ratio (FCR) =
Feed intake (g)/Wet Weight Gain (g)

5. Protein Efficiency Ratio (PER) =
Mean Weight Gain/Protein Intake

Where; Protein Intake = Feed Intake x % Protein in the diet.

6. Nitrogen Metabolism (Nm) = (0.549) (a+ b) h/2

Where; a = Initial mean weight of fish, b = Final mean weight of fish and h = Experimental period in days.

7. Net Protein Utilization (NPU) = Nb-No + Nm/Ib

Where, Nb = Nitrogen content of fish after experiment, No = Nitrogen content of fish before experiment, Nm = Nitrogen metabolism, Ib = Nitrogen of experimental diet and

Nitrogen content = Protein content/6.25

8. Productive Protein Value (PPV) =
Increment in body protein/Protein intake

9. Apparent Digestibility Coefficient (ADC) =
$10^2 – [10^2 X (1d/1f X Nf/Nd)]$

Where, Nd= Protein in diet, Nf= Protein in faeces, 1d=%Cr_20_3 in diet and 1f=%Cr_20_3 in faeces.

10. Survival Rate (SR) % =
(Initial number of fish stocked-Mortality)/Initial number of fish stocked x100

Design of Experiment and Statistical Analysis: Three replicates were assigned to each treatment using a completely random design of experiment to test for the differently processed LSMs. Data resulting from the experiment were subjected to one-way analysis of variance test (ANOVA) using Statistical Package for the Social Sciences (SPSS) Computer Software 1988 version 10 of the Chicago Illinois, USA) and correlation analysis. Separation of significant mean differences among individual means was done at P = 0.05 according to [31].

RESULTS

All the four methods used in processing leucaena seeds produced different results of proximate composition (Table 1) and the proximate composition of various diets prepared for the digestibility study is shown in Table 2. Sundried (SD) yielded the lowest crude protein value of 22.75% while soaked and sundried Leucaena seeds (SW) yielded the highest crude protein value of 36.01%, followed by toasted (TS) 33.25% then alkali treated (SA) 28.94%. Fat content of SD was highest (6.12%) followed by TS (5.97%) then, SA (5.35%) and least in SW (5.18%). Crude fibre content was highest in sundried leucaena seed (SD) 11.38%, followed by (TS) 9.53% then, (SA) 7.27% and least in SW (7.11%). Values for ash content were least in SW 3.74 %, followed by TS 4.07%, then 4.28% in SA and then 5.98% in SD. The calorific value was highest in toasted leucaena seeds (TS) with 2976.83 $Kcal^{-1}$ kg followed by SW (2899.76 $kcal^{-1}$ kg) then 2833.50 $Kcal^{-1}$kg in (SD) and least in alkali-treated seeds and sundried (SA) with 2803.61 $Kcal^{-1}$ kg. However, mineral contents was found highest in all regarding Potassium (K) with 1.74% in roasted leucaena seeds and least in SA with 1.52% while Sodium (Na) was found least in all as mineral ranged from 0.01% to 0.03% in SD and TS respectively.

All final values showed an increase in the crude protein values of the experimental fish fed differently processed LSM-based diets from 62.08% (initial) to

Table 1: Proximate and mineral composition of differently processed leucaena seed meal

	Parameters										
Method of Processing	Energy Kcal·Kg	Ash (%)	Moist. (%)	Crude Protein (%)	Crude Fibre (%)	Fat (%)	Na (%)	K (%)	P (%)	Cca (%)	Mg (%)
SD	2833.50	5.98	15.14	22.75	11.38	6.12	0.01	1.62	0.46	0.41	0.22
TS	2976.83	4.07	14.12	33.25	9.53	5.97	0.01	1.74	0.60	0.44	0.25
SW	2899.76	3.74	12.56	36.01	7.11	5.18	0.03	1.68	0.68	0.42	0.29
SA	2803.61	4.28	12.20	28.94	7.27	5.35	0.02	1.52	0.55	0.40	0.26

SD = Sundrying, TS =Toasting, SW = Soaking in Water and Sundrying, SA = Soaking in Alkaline solution and Sundrying

Table 2: Gross ingredient and proximate composition of digestibility diets

Ingredient ($g^{-}100g^{-}DM$)	SD	TS	SW	SA
Fish Meal	18.70	18.70	18.70	18.70
Soya Bean Meal (SBM)	20.62	20.62	20.62	20.62
Leucaena Seed Meal (LSM)	18.71	15.68	14.64	17.02
Ground Nut cake	18.56	18.56	18.56	18.56
Yellow Maize	20.22	20.22	20.22	20.22
Palm Oil	0.25	1.00	1.00	1.38
Bone Meal	0.25	1.00	1.52	1.00
Oyster shell	0.24	1.75	1.75	0.75
Vitamin Premix	0.45	1.47	1.99	0.75
Chromic Oxide (1%)	1.00	1.00	1.00	1.00
Proximate composition (g^{-1} $100g^{-1}DM$)				
Crude protein (%)	40.17	40.12	40.08	40.14
Crude fat (%)	3.47	2.18	2.03	3.01
Moisture (%)	9.36	8.87	9.11	9.04
Ash (%)	11.41	10.36	10.89	11.26
NFE (%)	9.63	8.45	9.16	8.82
Gross energy ($Kcal^{-1}$ Kg)	3032.44	3132.21	3001.58	3032.60
Calorific protein ratio	75.49	78.07	74.89	75.55

Table 3: Growth and nutrient utilization of *C. gariepinus* fed differently processed leucaena seed meal-based diets for 14 days

	Differently Processed LSM Based Diet					
Parameters	SD	TS	SW	SA	Mean	S.E. of Mean
Initial M W (g)	5.73±0.02	5.74±0.02	5.71±0.02	5.6±0.02	5.72	-
Final M W (g)	5.96±0.04	5.98±0.08	6.03±0.17	5.96±0.06	5.98	-
M W G (g)	0.23^{c}	0.24^{c}	0.32^{a}	0.28^{b}	0.27	0.01
W G (%)	3.86	3.75	5.31	4.70	4.52	0.03
Survival (%)	96.00	92.00	96.00	96.00	95.00	-
Feed Consumed. (g)/Fish	29.11^{a}	26.04^{b}	30.02^{a}	31.14^{a}	29.08	1.09
Feed Consumed. (g)/Fish/day	0.087^{bc}	0.081^{c}	0.089^{ab}	0.093^{a}	0.087	0.01
SGR (%)	0.131^{c}	0.137^{c}	0.182^{a}	0.161^{b}	0.153	0.01
PER ($X10^{-2}$)	1.98^{d}	2.30^{b}	2.66^{a}	2.25^{c}	2.30	0.14
FCR	1.27^{a}	1.09^{b}	0.94^{c}	1.11^{b}	1.10	0.07
Nm	44.92^{b}	45.04^{a}	45.12^{a}	4.73^{c}	44.95	0.09
NPU	7.03^{b}	7.02^{b}	7.23^{a}	7.04^{b}	7.08	0.05
ADC protein	66.86^{d}	69.21^{c}	73.57^{a}	1.93^{b}	70.39	1.48
ADC energy	64.18^{d}	67.50^{c}	70.18^{a}	8.67^{b}	67.63	1.27

Mean values with the same superscript in a row are not significantly different p>0.05

62.11% (TS), 62.32% (SD), 62.54% (SA) and highest in SW (63.34%) (Table 3). Values for crude fibre were found to generally decline compared with the initial value of 1.46% to 1.44% (SD), 1.42% (SW) and least in SA (1.41%) except TS (1.46%), which was same as that of the initial value. Final ash content was highest in SD (11.74%), followed by TS (11.69%) while the other two SW (11.56%) and SA (11.59%) is lower than the initial value (11.66%). The values for the final moisture contents indicated a general decrease compared with the initial value (14.52%). Final values for crude fat was least in SD (4.30%) while TS and SA had 4.31% and SW had 4.33% as the highest value.

However, mineral compositions of fish fed all the differently processed Leucaena seed showed little variations. Sodium (Na) varied between 0.28% in SW being the least followed by SD (0.29%), SA (0.03%) and TS (0.32%) the highest. Similarly, Potassium (K) had 0.60% being the least and highest in the initial value with 0.68%. Others were 0.66 % (SD), 0.64 % (TS) and 0.67% for SW. Phosphorus (P) varied in composition with 0.11% among the processed seed with the least being 0.88% in the initial value and 0.99% both for TS and SA. SD has 0.96% value while SW was 0.98%. Calcium (Ca) ranged between 1.72% in SD and 1.79% in SA. Magnesium (Mg) composition was highest in SW (0.98%) while others TS, SD and SA closely trailed each other with 0.80% 0.84% and 0.89% respectively

Experimental fish did utilize the four feeds at varying levels brought about significant variations ($p<0.05$) in some of the growth and nutrient utilization parameters considered. Mean weight gain (MWG) was least in SD (0.23g) followed by 0.24g in TS then 0.28g in SA and highest in SW with 0.32g. Fish fed TS diet consumed the least amount of feed 26.04g followed by 29.11g in SD then 30.02g in SW and highest in SA (31.14g). Fish survival rate was least in TS (92%) and highest in SD, SW and SA (96%) with total mean value of 95%. Specific growth rate (SGR) was highest in fish fed SW diet (0.182%) while it was least in fish fed SD diet (0.131%). Feed conversion ratio (FCR) ranged from 0.94 in SW fed fish to TS (1.09), SA (1.11) and SD (1.27) being the highest. Nitrogen metabolism (Nm) was highest in SW (45.12) and closely followed by TS (45.04) then 44.92 in SA but least in SD (44.73). NPU was highest in SW (7.23) leaving behind SA, SD and TS at 7.04, 7.03 and 7.02 respectively. The least value (0.01%) was recorded for SD and TS respectively while SA has 0.02% and SW has 0.03% as the highest Crude fibre was highest in SD (6.12%) and lowest in SW (5.18%) which is closely followed by SA (5.35%) while it was 5.97% in TS. Apart from sundried leucaena seeds (SD) which stood as control, toasted leucaena seeds (TS) had the highest value of crude fibre (1.46) while the other two processing methods involving water SW and SA recorded lower crude fibre values 1.42 and 1.41 respectively. Ash was highest in SD (5.98%) and lowest in SW (3.74%) while moisture content was highest in SD (15.14%) and lowest in SA (12.20%). Energy content ($Kcal^{-1}$ kg) was however highest in TS (2976.83 while it was lowest in SA (2803.61). Next to TS in value is SW (2899.76) and this was followed by SD (2833.50).

Table 4: Carcass and Mineral Composition of *C. gariepinus* Fed Differently Processed LSM Based Diets

Treatment	Crude Protein (%)	Crude Fibre (%)	Ash (%)	Moist. (%)	Crude fat (%)	Na (%)	K (%)	Ph (%)	Ca (%)	Mg (%)
Initial	62.08	1.46	11.60	14.52	4.27	0.31	0.68	0.88	1.74	0.83
SD	62.32	1.44	11.74	13.96	4.30	0.29	0.66	0.96	1.72	0.84
TS	62.11	1.46	11.69	14.44	4.31	0.32	0.64	0.99	1.74	0.80
SW	63.34	1.42	11.56	14.41	4.33	0.28	0.67	0.98	1.77	0.98
SA	62.54	1.41	11.59	14.01	4.31	0.30	0.60	0.99	1.79	0.81

SD = Sundrying, TS = Toasting, SW = Soaking in Water and SA = Soaking in alkaline and sundrying

Apparent Digestibility Coefficient (ADC) of protein (66.86) and energy (64.18) were least in SD while SA had 71.93 and 68.67 for ADC protein and energy respectively, which was significantly higher than those of TS 69.21 and 67.50 (ADC protein and energy respectively).

Protein efficiency ratio (PER) was significantly higher in SW (2.66) $p<0.05$ than value of other diets while the least was recorded in S (1.98) and TS and SA were 2.30 and 2.25 respectively. There was generally an increase in the protein content of the carcass of the experimental fish in all the treatments after the experiment (Table 4). Fish fed SW had 63.34% C.P while those fed SA had 62.54% while SD had 62.32% and TS had 62.11% (85%) did not yield commensurably a high digestibility coefficients and nutrient utilization by fish indicating its nutritional poor status

In similar way crude fat in the experimental fish was found to be highest in fish fed SW (4.33%) followed by TS and SA (4.31%) and least in SD (4.30). However, crude fibre (C.F) was highest in TS (1.46%) while it was least in SA (1.41%). The 1.41% recorded in SA was closely followed by SW (1.42%) while SD had 1.46% C.F which further showed that water processed leucaena seed is better utilized by fish than any other method especially, as against heat treatment. Mineral contents varied with little margins in all fish fed differently processed LSM-based diets. Initial value of sodium in experimental fish was found to be 0.31% and this fluctuated in the final values of fish. Fish fed SW, SD and SA lost 0.03%, 0.02% and 0.01% sodium respectively while it increased only in TS by 0.01%. Similar decrease in values of mineral content was observed with potassium having the initial value of 0.68%. SA lost 0.08% of potassium followed by TS (0.04%) and SD (0.02%) while SW lost the least (0.01%). There however seemed to be a general increasing trend in the values of calcium in the experimental fish except for SD which lost 0.02% of its calcium content. Other fish gained more calcium with 0.03% and 0.05% in SW and SA respectively while the calcium content remained constant in R. The magnesium content in the experimental fish also reduced in TS by 0.03% while it increased in SD, SA and SW by 0.01%, 0.06% and 0.15% respectively.

DISCUSSION

It was observed that the differences in the nutrient composition of the differently processed leucaena seeds consequently brought about different levels of digestibility and utilization by the experimental fish. This observation is similar to the work of [32], [33] and affirmed by [34]. Results on the nutrient compositions of the processed diets on proximate analysis and the consequent nutrient composition of the feed prepared especially, crude protein (C.P) concentration was reported to be over 30% in the seeds of leucaena [10] and this tends towards the values of C.P of two of the processed seeds by water treatment which are over 30% meaning that, SW and SA appear to have superior bio-chemical composition than the heat processed leucaena seed (TS) on average. Previous studies showed that simple soaking in water is the best processing method for legume seeds or grains generally as concluded by [35].

Phosphorus, a vital mineral in the synthesis of certain polyunsaturated fatty acids in leucaena [35, 36, 37] related directly with values of crude protein while Magnesium (Mg), an important component of â-carotene synthesis which is susceptible to heat [39] was higher in water treated leucaena seeds SW (0.29%) and SA (0.26%) while it was lower in heat treated seeds. This observation was similar to the report of [37] on the effect of different processing method on the retention of carotenoid fraction in *L. leucocephala* Values of Sodium (Na) are very low in all the processed seeds. The generally low values recorded for Na is the same with the reports of [35, 37, 38, 40].

Fibre content in the processed leucaena seeds used in the preparation of the diets was however inversely related to the digestibility values of the various diets utilized which was in line with the work of [41] when *Tilapia zillii* was fed with water hyacinth meal having

high fibre content. This was also similar to the report of [17] that identified high fibre content in the fodder of leucaena as a problem to effective utilization of leucaena meals. Results on crude fibre content was another clear distinction in LSM processed by heat and by water respectively. The report of [22] is in support of the energy content recorded in all the processed diet which was closely related to the energy requirement of catfish 3000 Kcal digestible energy^{-1} kg feed [42]. Thermal processing was said to have adverse affect on protein digestibility as observed in mustard oil seed cake [43], sunflower [44] and the Chinese oilseed [45] that were subjected to toasting or dry heating when fed to fish. Roasting (thermal treatment) could also distort the chemical structure of protein in feed ingredients as observed by [46] and [47] in their respective studies which were corroborated by [32] and [48] that heating solubilizes and reduces nitrogenous compounds in legume seeds.

Significant ($p<0.05$) variations recorded in the mean weight gain of fish is as a result of the extent of the digestibility of the feed which is similar to the findings of [49] and [50] who both recorded significant mean weight gain of experimental fish with higher digestibility values during their studies respectively. Fish fed SW based LSM exhibited significantly higher ($p<0.05$) digestibility value of both protein and energy and consequently significantly higher feed utilization potentials when other growth and nutrient utilization parameters were considered. However, digestibility values recorded during the study for processed LSMs utilization fell within range of values reported by [51], [52] and [53] when leucaena leaf meal (LLM) was fed to fish and further stressed that slight difference in digestibility values of animal feeds could result in significant difference in weight gain of fish.

In fact, each pair of the ADC protein and energy values of a processed seeds by a particular method is significantly higher than those of another pair and these reflect directly with SGR, PER, FCR, Nm and other parameters that were analyzed. This observed trend in the values of the nutrient utilization parameters consequent to variations in the digestibility potentials of the various diets prepared resembled the reports of [54] and [55]. Having confirmed the pattern of nutrient digestibility and its related utilization potentials in fish [56] and [30] from different studies concluded that digestibility of nutrients and energy contents in feedstuffs could be used to assess the suitability and nutritive value of feedstuffs or diets in fish instead of looking at growth responses to the test diet.

The trend in the values recorded for protein utilization efficiency was an indication of the extent to which the diets were well digested prior to its utilization. This can be attributed to the chemical compositions of each of the diets prepared out of the differently processed diets especially in terms of their crude proteins and crude fibre. Crude fibre exhibited inverse relationship with PER while the crude protein exhibited direct relationship with PER in all the experimental fish diets containing differently processed LSMs. This observation related directly with the reports of [10] who observed that constraint to the enhancement of the utilization of leaves and seeds of fodder trees resides chiefly in factors such as fibre content, the presence of anti-nutritive compounds and deficiencies of certain essential amino acids. [59] has described mimosine- an antinutritive substance present in Leucaena as a heat stable compound that can complex with pyridoxal phosphate or act as an amino acid antagonist, leading to disruption of catalytical action of B_6 –containing enzymes such as trans-aminases or complex with metal such as zinc [10, 59]. The recorded variations in the digestibility values and nutrient utilization of the processed LSMs has also been confirmed by [60] who indicated cold water treatment as the better method of processing leucaena for livestock feed utilization. Carotenoids are known to be very high in leucaena [61, 62] which affirmed by the result of the proximate analysis of the processed leucaena seed with relative high values of Magnessium and Phosphorus which are important elements in the synthesis of carotene. However, carotene has been described to be a heat labile compound and that can be degraded by heat, acids, alkalis and oxidation [6, 10]. This assertion thus becomes germane to significant ($p<0.05$) better nutrient utilization exhibited by fish fed SW over SA and TS considering their levels of digestibility of protein and energy and feed utilization even though the crude protein values for TS and SA were very close to that of SW on laboratory analysis.

It is apparent from the fore going that leucaena seeds are better processed by soaking in water (SW), which correspondingly conferred better utilizations by catfish during this study. This result could be linked with variations in the left over mimosine contents of the various LSMs after processing as confirmed by [23] in a similar study on broiler chicks while [63] asserted that utilization of unconventional feedstuffs in fish diets depends on digestibility and availability of nutrients present in it among other factors and corroborated by [64] in another study.

Values of carcass protein from water treated leucaena seeds were higher than others processed by other methods showing a body protein gain of 0.24 and 0.03% respectively. It was very obvious in this manner that heat-treated seeds (TS) had the lowest value which could be adduced to the probable poor status of the nutrients in the diet due to destruction of amino acid bonds present in it thereby rendering it unavailable for better utilization. This evidence of unavailability of nutrient due to amino acid destruction was equally observed in the work of [33] in the processing of feather meal which despite its high crude protein content.

This general trend in the loss of minerals in the experimental fish was in conformity with the reports of [38] and [39], on the characteristic deficiency of sodium and further corroborated by [65]. [66] reported that sodium-based extracting agent was capable of reducing mimosine in leucaena up to 88%. This meant the reduction in the sodium content of the processed seeds was directly related to reduction in the mimosine content of each of the LSMs. The general increasing level of magnesium on the other hand seemed to correspond directly to the general increase in the level of phosphorus in all treatments. This was in line with the reports of [44] and [60] on the richness of its phosphatides and glycolipids respectively while [18] and [17] explained that leucaena was rich in many carotenoids, sterols and á-tocopherol of which magnesium is a basic component and the sharp difference in the value of phosphorus of SW-fed fish compared with others could be a reflection of the effect of processing methods on the release of phosphorus in each of the diets. However, the marginal differences in the carcass yield and mineral composition in all the experimental fish under differently processed LSM-based diets supported the work of [52] who recorded non-significant difference in the carcass composition and mineral depositions of *C.gariepinus* fingerlings fed chemically preserved shrimp head waste silage diets.

Finally, it is evident that soaking in water and later sundrying leucaena seeds is a better method of processing it for use in the preparation of fish feed. It improved the crude protein content of its meal and consequently, produced a superior digestibility coefficients and nutrient utilization values to other methods of processing.

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