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Growth performance and cost-effectiveness of replacement of fishmeal with plant-based protein source, *Leucaena leucocephala* in the diet of *Clarias gariepinus* fingerlings

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Abstract. *Agupugo CS, Nsofor CI, Ezewudo BI, Edeh IC. 2022. Growth performance and cost-effectiveness of replacement of fishmeal with plant-based protein source,* Leucaena leucocephala *in the diet of* Clarias gariepinus *fingerlings. Asian J Agric 6: 28-34.* The present study was conducted to determine the effects of the replacement of fishmeal with *Leucaena leucocephala* (Lam.) de Wit leaf meal (0%, 10%, 20%, and 30%) on fish growth and to compare the cost-effectiveness of replacement of fishmeal with *Leucaena* leaf meal in fish diets. The proximate value of the tested leaf meal showed moderate contents of crude protein and low contents of crude ash. The daily and mean weight gains of fish showed that the highest weight gains were recorded in fish fed with diet T3 (20%), while the least values were in fish fed with diet T4 (30%), and the differences were not significant (P>0.05). The highest survival rate was observed in fish fed with diet T1 (0%), while fish fed with T2 (10%) and T4 had the lowest values. The highest specific growth rate was obtained in diet T1. However, the highest food conversion ratio was recorded in fish fed with diet T4. The highest expenditure was recorded in diet T1. Our findings showed that using *Leucaena* leaf meal in the fish diet is best at a 20% inclusion level for optimum growth. *Leucaena*-containing diets were more cost-effective than a diet with only fishmeal.

Keywords: African mud catfish, cost-benefit, growth indices, leaf meal, nutrient utilization

INTRODUCTION

The aquaculture industry is rising, with an estimated yearly increase of 7% (Chen et al. 2019). Furthermore, for this growth to be sustained, there is a need for the availability of sustainable and economical aquafeeds to fish farmers. Its demands have also increased following the rise in the aquaculture industry (Mensah et al. 2018). Fishmeal, a major protein source in formulated fish diets, has also faced high demand, and it is mainly obtained through capture fisheries from marine and freshwater fish species (Tacon et al. 2006). The recent declines in wild fish stocks, such as the historic collapse of Peruvian anchovies (Ferguson-Cradler 2018), have created an artificial scarcity of fishmeal, culminating in an upsurge in fishmeal cost on fish feed production (Ezewudo et al. 2015). Notably, approximately 10% of the world's fish production is utilized as fishmeal in aquaculture, and this percentage falls short of its high market in fish feed production (FAO 2012). High demand, high cost, and unstable demand and supply emphasize the need to utilize plant proteins as an alternative source of protein to fishmeal in fish diets for sustainable growth of the aquaculture industry.

Leucaena leucocephala (Lam.) de Wit, commonly known as *Leucaena* or white lead tree, is one of the suitable plant protein alternatives to fishmeal for fish feed due to its medium-high protein content, suitable levels of amino acids and, most importantly, very affordable market price tag (De Angelis et al. 2021). However, few studies have demonstrated that *Leucaena* leaf meal can successfully replace fishmeal as a protein source in fish diets at different inclusion levels (Bairagi et al. 2004; Tiamiyu et al. 2015; Babalola and Fakunmoju 2020).

Clarias gariepinus (Burchell, 1822), commonly known as mud catfish or African sharp-tooth catfish, is an omnivorous fish, feeding on fruits, seeds, and varieties of aquatic organisms, including invertebrates, vertebrates, and planktons (Skelton 2001; Odongo et al. 2019). It is widely adopted as a culturable species in Nigeria because of its hardy nature and good feed conversion rate (Sotolu and Faturoti 2011). Fish is in high demand by fish consumers due to the tasty nature of the flesh (Idodo-Umeh 2003). However, a hike in the cost of fishmeal (a major protein source in fish diets) has increased the cost of production, leading to a low supply of fish to consumers. Therefore, this present study was conducted to determine the effects of the partial replacement of fishmeal with plant protein. *Leucaena* leaf meal on growth and nutrient utilization in *C. gariepinus* and compare the cost-effectiveness of the utilization of *Leucaena* leaf meal with that of fishmeal in the diets of *C. gariepinus*.

MATERIALS AND METHODS

Preparation of leaf meal and formulation of experimental diets

Fresh leaves of *L. leucocephala* (Figure 1) planted in Nnamdi Azikiwe University, Awka, Nigeria, were plucked from their branches and taken to the Botany laboratory for identification and authentication (Herbarium No NAUH 206[A]). The plucked leaves were carefully washed and later immersed in clean water for three days to reduce the levels of anti-nutritional elements in most plant proteins. At the end of the three-day immersion, the leaves were sun-dried until they became crispy, and with the aid of a corn milling machine, the leaves were ground into powder. Finally, the milled *Leucaena* leaves were sieved with a hand sieve to obtain fine powder from the milled leaves containing a tiny leaf. The proximate composition of *L. leucocephala* leaves (Table 1) was estimated to determine the total crude protein content, ash, moisture, carbohydrate, fiber, and fat content according to the Association of Official Analytical Chemists (AOAC 2012).

Four experimental diets were formulated according to the protein contents of fish meal, soybean, cornmeal, *Leucaena* leaf meal, and wheat offal by adopting the Pearson Square method (Pearson 1976), as highlighted in Table 2. In addition, *L. leucocephala* leaf meal was partially incorporated in the diets at 0% (the control diet), 10%, 20%, and 30%. The ingredients, such as fishmeal, soybean, cornmeal, etc., purchased from a popular market known as Afor-Nnobi in Idemili South Local Government Area, Anambra State, Nigeria, were used in formulating the diets. First, the formulated diets were weighed, and with the addition of water, the diets were homogenized to give a dough-like paste. Then, with the aid of a 3 mm electronic pelletizer, the diets were pelletized, sun-dried, and packed in airtight plastic containers at 4°C. The formulated diets were later analyzed for proximate compositions (Table 3) following the Association of Official Analytical Chemists (AOAC 2012).

The experimental site, fish, and design

The study was carried out in the Department of Zoology Fish ponds, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. African catfish (*C. gariepinus*) fingerlings were procured from a commercial fish farm in Awka, Awka South Local Government Area, Anambra State, Nigeria. A total of 140 fingerlings with an average weight of 3.6 g and an average length of 8.14 cm were procured and transported in a plastic gallon with well-oxygenated water. The fish were acclimatized for one week in 70 L plastic tanks and fed with commercial fish pellets (Coppens) of 0.8 mm before the commencement of the feeding trial.

At the expiration of the acclimation period, the weights of the remaining fingerlings were obtained electronically (SF-400), and uniform sizes were distributed without being biased in 12 (70 L) plastic tanks for the commencement of the feeding trial. For the feeding trial, 120 fingerlings were used. A 4×3 completely randomized design (CRD) was adopted following the formulation of four (4) dietary inclusion levels of *L. leucocephala* at 0%, 10%, 20%, and 30%. Thirty (30) fingerlings were assigned to each of the treatment diets, and each treatment was replicated thrice such that each replicate had ten fingerlings and placed in a well-netted tank to prevent fish from jumping out. Pipe-borne water was used as the main source of water.

The fish was fed twice daily, between 8.00 am and 6.00 pm. The feeding was at 5% body weight, which was adjusted as they improved in weight. Caution was applied to ensure no left-over feed by siphoning any left-over feed. At the same time, total cleaning of the experimental tanks and the introduction clean water were done twice weekly. The whole research lasted for ten weeks.

Table 1. Proximate values of *Leucaena leucocephala* leaf meal

Parameters	*Leucaena leucocephala* (%)
Crude protein	21.49
Crude fat	3.37
Crude fiber	17.08
Ash	9.88
Moisture	12.34
Dry matter	87.66
Nitrogen free extract	34.85

Table 2. Percentage compositions of *Leucaena leucocephala* leaf meal in the experimental diet

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4
Fishmeal (g)	41	37	33	29
Soyabean (g)	27	27	27	27
Corn meal (g)	16	16	16	16
Leucaena leaf meal (g)	0	4	8	12
Wheat offal (g)	10	10	10	10
Methionine (g)	0.25	0.25	0.25	0.25
Lysine (g)	0.25	0.25	0.25	0.25
Starch (g)	2	2	2	2
Salt (g)	0.25	0.25	0.25	0.25
Bonemeal (g)	1	1	1	1
Vitamin premix (g)	0.25	0.25	0.25	0.25
Vegetable oil (g)	2	2	2	2
Total (g)	100	100	100	100
Inclusion levels of *Leucaena* leaf meal (%)	0	10	20	30

Figure 1. *Leucaena leucocephala* leaves with pods

Table 3. Proximate contents of inclusion levels of *Leucaena leucocephala* leaf meal formulated diets

Parameters	T1 (0% L.L.M)	T2 (10% L.L.M)	T3 (20% L.L.M)	T4 (30% L.L.M)
Crude protein	37.17	36.69	37.38	36.78
Crude fat	3.81	3.64	3.76	3.55
Crude fibre	2.11	3.06	2.08	3.14
Ash	7.78	6.94	7.86	6.89
Moisture	8.29	9.11	8.22	9.14
Dry matter	91.71	90.89	91.78	90.86
NFE	37.94	37.56	37.7	46.5

Note: NFE = Nitrogen-free extract. L.L.M = *Leucaena* leaf meal, T1 = (fishmeal as control), T2 = (fishmeal + 10% leaf meal), T3 = (fishmeal + 20% leaf meal), T4 = (fishmeal + 30% leaf meal)

Water quality monitoring

The water temperature was monitored daily with a mercury-in-glass thermometer and recorded to the nearest Celsius (ºC). In addition, the pH of the water was taken weekly using a pH meter (Hanna- H198129), and the dissolved oxygen in each experimental tank was determined using YSI dissolved oxygen meter. During the experiment, the water temperature ranged from 26.67-27.79ºC, pH 6.28-6.48, and dissolved oxygen 3.95-4.27.

Determination of growth and feed utilization of fish

The following growth and feed utilization indices were computed before and after the feeding trial on each diet following the formulae reported in Ezewudo et al. (2015).

$$\text{Daily weight gain (g/fish)} = \frac{FW - IW}{7 \text{ days}}$$

Where FW = Final weight (g/fish) and IW = Initial weight (g/fish)

$$\text{Mean weight gain (g/fish)} = FMW - IMW$$

Where IMW = Initial mean weight (g/fish) and FMW = Final mean weight (g/fish)

$$\text{Mean Length gain (cm/fish)} = FML - IML$$

Where IML = Initial mean length (cm/fish) and FML = Final mean length (cm/fish).

$$\text{Specific growth rate} = \frac{\log_e FMW - IMW}{T} \times 100$$

Where $\log_e$ = natural logarithm; IMW = initial mean weight (g/fish); FMW = final mean weight (g) and T = total duration of the experiment

$$\text{Relative growth rate (RGR)\%} = \frac{FW - IW}{IW} \times 100$$

Where IMW = Initial mean weight (g/fish) and FMW = Final mean weight (g/fish)

$$\text{Survival rate (\%)} = \frac{Nf \times 100}{Ni}$$

Where Ni = Number of fish at the beginning of the experiment and Nf = Number of fish at the end of the experiment

$$\text{Food conversion ratio (FCR)\%} = \frac{\text{Total food fed to fish (g)}}{\text{Total weight gain by fish (g)}}$$

Food intake is the amount of food fed to the fish – food left-over; this is done daily by siphoning the left-over food, drying and reweighing them to ascertain the quantity eaten by fish.

Cost-benefit analysis of the production of experimental feed

Cost per kilogram of feed types = Quantity of each ingredient × cost of 1 kg of the ingredient/quantity of feed formulated (1000 g).

Cost of feed consumed per fish = Total food consumed per fish × feed cost per kilogram.

Expenditure per fish = Fish-cost of 1kg in the market + cost of food consumed by the fish.

Statistical analysis

All data obtained were subjected to one-way Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS), Version 23 for Windows. Differences in means were separated using Duncan's new multiple-range test. The significant difference was established at a 5% probability level (*P*<0.05), while the results generated were expressed as mean ± standard deviation (SD).

RESULTS AND DISCUSSION

Determination of growth and feed utilization of fish

The daily and mean weight gains of fish fed with different inclusion levels of *L. leucocephala* leaf meal showed that all the fish in each treatment recorded progressive weight gains (Table 4). The highest daily and mean weight gains were recorded in fish fed with diet T3 containing 20% inclusion levels of *Leucaena* leaf meal (4.3±1.127 g and 30.10±7.894 g), while most minor increases were observed in those fed with diet T4 (3.23±0.587 g and 22.60±4.355 g). There was no significant difference (*P*>0.05) in weight gains of *C. gariepinus* fingerlings fed with the different experimental diets.

There was a progressive increase in the weekly length increase of *C. gariepinus* fed varying inclusion levels of *L. leucocephala* leaf meal for ten weeks (Table 4). The highest mean length increase (9.12±1.41 cm) was recorded in fish fed with diet T, while those fed with diet T4 recorded the least mean length increase (8.14±0.70 cm) (Table 4). The analysis of variance result revealed no significant difference (*P*>0.05) between the mean length gains of *C. gariepinus* fed varying inclusion levels of *Leucaena* leaf meal.

Data from the specific growth rate of *C. gariepinus* fingerlings fed with varying concentrations of *L. leucocephala* feed meal revealed that the highest specific growth rate was obtained in diet T1 (4.85±0.267%). In contrast, the lowest was generated in those fed with diet T4 (4.44±0.272%), and the differences were not significant (*P*>0.05) (Table 4). Furthermore, the highest relative growth rate (872.57±181.502%) was obtained in fish-fed diet T1 (control diet) while the least value (647.76±134.433%) was recorded in those fed with diet T4 and the differences were non-significant (*P*>0.05) (Table 4).

Mortality was observed during the feeding trial. However, the highest survival rate (96.66±1.93%) was recorded in diet T1 (control diet), while the lowest values (90.0±5.77%) were observed in fish fed with diets T2 and T4, and the differences were significant (*P*<0.05) (Table 4).

The results of total feed consumed by *C. gariepinus* fingerlings fed with the four experimental diets for ten weeks revealed that the mean feed intake of *C. gariepinus* fingerlings was highest (7.10±0.319 g) in those fed with the diet T3, while the lowest value was obtained in those fed with diet T4 (6.28±0.887 g). Differences were significant (*P*<0.05) (Table 5). In addition, the highest feed conversion ratio was recorded in *C. gariepinus* fingerlings fed with the diet T4 (0.28±0.014%), while the least value (0.23±0.01855%) was recorded in those fed with diet T1 and the differences were not significant (*P*>0.05) (Table 5).

Cost of production of the four feed types for profitable maintenance of aquaculture

Upon the completion of the feeding trial, cost-benefit production of fish (*C. gariepinus*) fingerlings fed four dietary treatments of *Leucaena* leaf meal were compared using the following indices: cost/kg, cost of total feed consumed, and expenditure (Table 6). The highest cost/kg, total feed consumed, and expenditure was recorded in diet T1, followed by diet T2, and the lowest values were obtained in diet T4 (Table 6).

Discussion

The appreciable contents of crude protein, crude fats, crude fiber, and ash in *Leucaena* leaf meal suggest that this leaf in animal diets can provide the required proteins, minerals, dietary fiber, and essential fatty acids needed for animal metabolism as efficient growth and improve food digestibility. The crude protein of the tested leaf meal of 21.49% compares well to the 21.49-22.29% reported by De Angelis et al. (2021). However, the present crude protein content is far from the 22.67-29.17% recorded by Adekojo et al. (2014). The variations in crude protein content of *Leucaena* leaf meal, as reported by different researchers, could be attributed to the nutritional constituents of the soil on which the plant was grown, the age of cultivars, and the processing methods deployed before proximate composition analysis of the leaf meal (Ayssiwede et al. 2010; Adekojo et al. 2014; Figueredo et al. 2019). According to Adekojo et al. (2014), variations in proximate compositions of *Leucaena* leaf meal depend on the different processing methods, namely air-drying; soaking in fresh water at room temperature for 36 hours; soaking in hot water for 24 hours and fermenting for five days.

Table 5. Effect of partial replacement of fishmeal with four levels of *Leucaena leucocephala* leaf meal on feed utilization of *Clarias gariepinus*

Treatments	Mean feed intake (g)	Mean FCR (%)
T1: Control	6.82±0.746[b]	0.23±0.018
T2: 10% *Leucaena* leaf meal	6.98±0.232[b]	0.26±0.009
T3: 20% *Leucaena* leaf meal	7.10±0.319[b]	0.24±0.052
T4: 30% *Leucaena* leaf meal	6.28±0.887[a]	0.28±0.014

Note: Different letters in one column mean significant differences at *P*<0.05. Absent of letters means no significant differences between treatments

Table 6. Cost-benefit production of fish (*Clarias gariepinus*) fingerlings fed four dietary treatments of *Leucaena leucocephala* leaf meal

Parameters	T1	T2	T3	T4
Cost of 1 kg fish ($)	2.92	2.92	2.92	2.92
Mean initial weight (g)	3.47	3.83	3.63	3.50
Mean final weight gain (g)	30.07	26.70	30.10	22.60
Cost/kg feed ($)	5.60	5.10	4.63	4.16
Cost of total feed consumed ($)	0.37	0.35	0.32	0.27
Expenditure ($)	3.29	3.27	3.24	3.19

Note: T1 = (Fishmeal as control), T2 = (Fishmeal and 10% leafmeal), T3 = (Fishmeal and 20% leafmeal) and T4 = (Fishmeal and 30% leafmeal)

Table 4. Effect of partial replacement of fishmeal with four levels of *Leucaena leucocephala* leaf meal on growth performance of *Clarias gariepinus*

Treatments	Daily weight gain (g)	Mean weight gain (g)	Mean length gain (cm)	Specific growth rate (%)	Relative growth rate (%)	Survival (%)
T1: Control	4.29±0.715	30.07±5.314	9.12±1.41	4.85±0.267	872.57±181.502	96.66±1.93[c]
T2: 10% *Leucaena* leaf meal	3.81±0.108	26.70±0.872	8.83±0.48	4.69±0.047	698.99±48.065	90.0±5.77[a]
T3: 20% *Leucaena* leaf meal	4.3±1.127	30.10±7.894	8.97±1.83	4.83±0.371	826.45±203.756	93.33±3.58[b]
T4: 30% *Leucaena* leaf meal	3.23±0.587	22.60±4.355	8.14±0.70	4.44±0.272	647.76±134.433	90.0±5.77[a]

Note: Different letters in one column mean significant differences at *P*<0.05. Absent of letters means no significant differences between treatments

The crude fat content of the present study was lower than the 5.65% reported by Malik et al. (2019). Malik et al. (2019) further reported that the seeds of *L. leucocephala* contain more fats than their leaves; however, the latter is richer in nutritional fats, especially polyunsaturated fatty acids, than saturated fatty acids. The crude fat present in *Leucaena* leaf meal was observed when *Leucaena* leaf meal was used in replacing a commercial broiler finisher diet in the diets of black australorp and Potchefstroom koekoek chicken (Thamaga et al. 2021). These authors reported an increase in the levels of crude fats in diets with *Leucaena* leaf meal compared with the control diet (0% *Leucaena* leaf meal). The moderate ash level in the tested leaf meal shows that it is well endowed with minerals. Thamaga et al. (2021) showed that the *Leucaena* leaf meal is rich in essential minerals like copper, manganese, zinc, and iron but contains a lesser amount of calcium, magnesium, potassium, and sodium.

The crude fiber reported in this current study was higher than the 13.85% reported by Adedeji et al. (2013) but lower than the 19.20% reported in the work of Babalola and Fakunmoju (2020). The improved crude fiber in the tested leaf meal can aid bowel movement, favoring nutrient absorption and reducing constipation (Lunn and Buttriss, 2007; Amobi et al. 2019).

The proximate contents of the experimental diets showed that they were rightly formulated to provide the necessary nutrient for optimum fish growth. The crude protein of *Leucaena* leaf meal-reinforced diets (36.69-37.38) is quite close to 35.08-36.81 observed by Tiamiyu et al. (2015). The results from the present study on crude protein (CP) and ash showed that the highest CP and ash were recorded in diet T3 with 20% *Leucaena* leaf meal against the control diet with 0% *Leucaena* leaf meal. This increase indicates that better right contents of crude protein and minerals could be achieved at a 20% inclusion level against the other concentration levels (0%, 10%, and 30%). However, despite the moderate contents of crude protein and minerals in the *Leucaena* leaf meal, it was observed that the inclusion of *Leucaena* leaf meal above 20% recorded a decrease in crude protein and ash. The processing method adopted for the Leucaena leaf meal could better explain this result. According to Adekojo et al. (2014), the sun-drying method used in this study contains more anti-nutritional elements like mimosine, capable of removing essential nutrients, unlike other processing methods like immersion in freshwater, soaking in hot water and fermentation.

High fiber content was recorded in the diet with a 30% inclusion level of *Leucaena* leaf meal against the control, while the crude fat was highest in diet T1 with 0% *Leucaena* leaf meal. This result is not surprising since the *Leucaena* leaf meal is enriched with fiber (Malik et al. 2019), while the high crude fat recorded in diet T1 could be attributed to high-fat contents present in animals than in plants (Nnamonu et al. 2020).

Fish is one of the animals known to adapt to various nutritional states. The ability of fish to accept, utilize and convert the food given to it for optimum growth and productivity is best studied using growth and feed utilization indices (González-Rodríguez et al. 2014; Chen et al. 2019). Fingerlings fed with a 20% inclusion level of *Leucaena* leaf meal (diet T3) had the best daily and mean weight gains. That could be attributed to the highest crude protein and ash recorded in this diet and elevated level of crude fat, which supports anabolic processes like growth and deposition of fat. The highest weight gain recorded in fish fed with a 20% inclusion level of the *Leucaena* leaf meal can also be associated with the high acceptability and palatability of the feed. Moreover, fish fed this diet had the highest mean feed intake than those fed with varying concentrations of the tested leaf meal. This finding agrees with Amisah et al. (2009) and Tiamiyu et al. (2015). These authors reported that the inclusion level of *Leucaena* leaf meal at 20% did not negatively alter the weight of fish but instead gave the best weight gain. The best specific growth rate and mean length gain recorded in fish fed with a control diet may be attributed to high amino acids present in fishmeal than in plant proteins. Schulz et al. (2007) opined that incorporating high levels of plant proteins against the conventional fishmeal in fish diets is associated with retarded growth performance. Furthermore, according to Reigh (2008), plant proteins possess lower amino acid profiles than animal proteins like fishmeal, which are already replaced.

High survival rates recorded in this study could be due to the proper handling of the fish and proper water quality management. However, fish fed with diets T1 and T3 had the best survival rates, indicating the suitability of these diets for fish. According to Tiamiyu et al. (2015), high fish survival rates in experimental trials are good indicators of the proper handling of fish, the suitability of the diets for fish, and good water quality management.

Growth in animals does not only manifest when the right food is given but also depends on the ability of the animal to efficiently convert the food given into tissues and muscles for optimum growth (Olivotto et al. 2003). The lowest food conversion ratios recorded in diets T3 and T1 indicate that fish fed with these two diets did not effectively convert their food to body growth than those fed with diet T4, which had the highest food conversion ratio (Fry et al. 2018). The lowest food conversion ratios recorded in diets T3 and T1 could be likened to low crude fiber, elevated crude protein, and low levels of anti-nutritional elements, which promote or support food digestibility (Hermawan et al. 2021). On the other hand, diet T4, with 30% inclusion levels of *Leucaena* leaf meal which recorded the highest food conversion ratio, could be attributed to high fiber contents in the diet due to the high inclusion level of plant protein (*Leucaena* leaf meal), low crude protein and high levels of nutrient-inhibitory elements like saponin and mimosine leading to poor digestibility and palatability (Agbo et al. 2011).

The cost-benefit production of fish (*C. gariepinus*) fingerlings fed four varying concentrations of *Leucaena* leaf meal showed that the cost per kilogram of feed types, cost of feed consumed per fish, and expenditure per fish decreased with an increase in inclusion levels of *Leucaena* leaf meal. That was due to the high cost of the fish meal, which was higher in the control diet than the three remaining diets containing varying concentrations of *Leucaena* leaf meal. The cost-effectiveness assessment of the current work clearly showed that *Leucaena*-reinforced diets are cheaper than the control diet; however, the 20% inclusion level of *Leucaena* leaf meal was more profitable with the best weight gain than the other remaining diets. This finding suggests that more monetary profits and better productivity await a fish farmer when 20% of *the L. leucocephala* leaf meal is incorporated into the fish diet to replace fishmeal. This result agrees with the finding of Agbo et al. (2011), who reported more profit in fish diets incorporated with cottonseed meal than in the control diet with only fishmeal.

In conclusion, findings from this present study indicated that the *Leucaena* leaf meal is highly nutritious and can be incorporated into animal diets, including fish as a feed ingredient. However, its utilization in fish diets is best at a 20% inclusion level for optimum growth and efficient feed utilization. In contrast, higher incorporation of the leaf meal in fish diets could retard fish growth due to high fiber contents and anti-nutritional elements in the leaf meal. Additionally, diets containing *Leucaena* leaf meals were more cost-effective than those with fish, especially at a 20% inclusion level of *Leucaena* leaf meal. Based on the current findings, we suggest replacing fishmeal with *Leucaena* leaf meal at a 20% inclusion level be adopted in fish diet formulation for more monetary profits and better productivity. Future research should focus on evaluating the potency of *L. leucocephala* seeds as feed ingredients in fish diets and compare their growth performance to those fed with *L. leucocephala* leaf meal.

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