Dietary effects of *Gliricidia sepium* leaf meal on *Clarias gariepinus* (Burchell, 1822) fingerlings

John B. Olasunkanmi[1*], Olumide T. Julius[1], Jeremiah O. Jimoh[1], Ademola M. Akinsorotan[1], Tolulope O. Ariyomo[1], Oluwatosin H. Tope-Jegede[1], Olubunmi G. Sodipe[2] and Fabusoro A. Ayodeji[1]

[1]*Department of Fisheries and Aquaculture, Faculty of Agriculture Ikole-Campus, Federal University, Oye-Ekiti, Ekiti State, Nigeria.*
[2]*Department of Animal Production and Health, Faculty of Agriculture Ikole-Campus, Federal University, Oye-Ekiti, Ekiti State, Nigeria*

**Corresponding author email:* john.olasunkanmi@fuoye.edu.ng.

This study investigated the feed potential of *Gliricidia sepium* leaf meal (GLM) for *Clarias gariepinus* fingerlings. Five isonitrogenous 40% crude protein diets were formulated where GLM replaced Soybean meal at 0 (control), 25, 50, 75, and 100% inclusions. Ten *C. gariepinus* fingerlings (6.85 ± 0.37g) were randomly stocked into each of 15 plastic aquaria with three aquaria for each diet. The fingerlings were fed twice daily at 5% of their body weight for 56 days between the hours of 8:00 – 9:00 and 16:00 – 17:00. Fish fed the control diet recorded highest values for the growth parameters and best values for haematological indices and there were significant variations (P ≤ 0.05) in the growth performance parameters and haematological indices between the control and other treatments. The inclusion of raw GLM in the diet of *C. gariepinus* fingerlings had adverse effects on the growth and haematology profile of the fish. Processing of the leaf meal is recommended for future study.

Keywords: Feed potentials, soybean meal, growth parameters, haematology

Developing countries are faced with the problem of an ever-increasing population without a corresponding increase in animal protein production and the gap between the recommended protein intake and the average consumption rate has led to an increase in demand for animal protein by Nigerians (Olopade et al. 2015). In meeting this demand, fish has been identified as a cheap source of good quality animal protein in many developing countries including Nigeria (Temesgen 2004). Fish possesses great potential for reducing the protein deficiency in the developing world especially Nigeria **(**Chan et al. 2019) where sources may be from the wild or through fish farming/ aquaculture. According to FAO (2006), fish supplies from capture fisheries can no longer match the increasing demand for aquatic foods globally and for this reason, a sustainable alternative system is needed for fish production that will meet this demand.

Aquaculture has been identified as an alternative production to meet fish demand, however, Akinrotimi et al. (2007) opined that as the intensity of aquaculture production increases, fish feed will be a major factor that will affect productivity and profitability. Availability of good quality fish feed is an important factor in aquaculture: it plays a major role in the provision of high-quality fish products (Speranza et al. 2021).

The high cost of fish feed is one of the problems militating against the development of aquaculture (Tiamiyu et al. 2015). This high cost is a result of scarcity and unaffordable cost of some conventional protein feedstuffs such as soybean due to an ever-increasing demand as staple foods for humans, raw material in industries, and as feed ingredients in farm animals.

Expensive feeds will significantly reduce the profitability of aquaculture production, consequently reducing yield in both qualitative and quantitative terms (Asiedu et al. 2019). The high cost of soybean and other conventional feedstuffs, coupled with scarcity due to demand, calls for the need to obtain an alternative protein feed in order to sustain aquaculture. The drive to discover alternative feedstuffs that do not compete with human food needs has fuelled interest in the exploitation of various leaf meals for their potential (Sandström et al. 2022).

0041–3216/2024/040487–496

Gliricidia sepium is a leguminous browse plant with relatively high protein content which has been used solely or combined with other feed ingredients to feed livestock and poultry in different proportions and forms with satisfactory results (Sarkwa 2020). *G. sepium* leaves have a high nutritional value with crude protein comprising 20 - 30% of dry matter, crude fibre content of 8.61%, ether extract of 12.29% and a nitrogen free extract of 40.21% (Adejumo and Ademosun 1985; Aye and Adegun 2013). This plant is abundant in many parts of Nigeria and the leaves are readily available for harvest at little or no cost making it a suitable alternative feed for reducing the cost of fish production. This study aimed at assessing the performance of *Clarias gariepinus* fed *Gliricidia sepium* leaf meal.

Materials and methods

Collection and processing of *Gliricidia sepium* leaves

G. sepium leaves were freshly procured from the campus of Federal University Oye-Ekiti, Ikole Campus, Ekiti State, Nigeria, and air dried for 21 days at room temperature. The dried *G. sepium* leaves were milled after drying to reduce particle size and ensure homogeneity when mixing with other feed ingredients. The grinded *G. sepium* leaves were stored in a polyethylene bag until needed for feed manufacturing.

Diet formulation

Five isonitrogenous (40% protein) feeds were formulated. *G. sepium* leaf meal **(**GLM) replaced soybean meal at 0% (Diet 1/control), 25% (Diet 2), 50% (Diet 3), 75% (Diet 4) and 100% (Diet 5). Multizyme Pro (an exogenous enzyme) was added to the diet as a fixed ingredient to ameliorate the effect of the fibre in the diet. The ingredients were milled, weighed, mixed thoroughly and water was added before pelleting. The pellets produced were sundried to constant weight, and the dried pellets were stored in airtight polythene bags and kept in a cool dry place prior to use. The diets were formulated as shown in Table 1.

Table 1: Percentage composition of experimental diets

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Maize	8.48	8.48	8.48	8.48	8.48
Wheat offal	8.48	8.48	8.48	8.48	8.48
Soybean	24.17	18.13	12.085	6.04	0.0
GLM	0.0	6.04	12.085	18.13	24.17
Groundnut cake	24.17	24.17	24.17	24.17	24.17
Fish Meal (65% crude protein)	24.17	24.17	24.17	24.17	24.17
Methionine	1.0	1.0	1.0	1.0	1.0
Starch	2.0	2.0	2.0	2.0	2.0
Vitamin premix	2.0	2.0	2.0	2.0	2.0
Vitamin C	0.03	0.03	0.03	0.03	0.03
Salt	0.4	0.4	0.4	0.4	0.4
Vegetable Oil	5.0	5.0	5.0	5.0	5.0
Multizyme Pro*	0.1	0.1	0.1	0.1	0.1
Total	100	100	100	100	100

GLM: *Gliricidia sepium* leaf meal
***Alpha-amylase EC 3.2.1.1, beta-glucanase EC 3.2.1.6, beta-glucanase EC 3.2.1.4, xylanase EC 3.2.1.8 and phytase.

Experimental design and feeding trials

A total of 150 *Clarias gariepinus* fingerlings (6.85 ± 0.37g) were purchased from Mercy fish farm in Ado-Ekiti and transported to the wet laboratory, Department of Fisheries and Aquaculture, Federal University Oye-Ekiti, Ikole Campus, Ekiti State, Nigeria. The fish were acclimatised for 14 days and were fed commercial feed (VitalFeed®) at 5% body weight during this period. At the end of the acclimatisation period, the fish were randomly selected and batch weighed into 15 rectangular (18 x 13 x 14 inches) aquaria holding ten fishes each with three acquaria for each diet. The trial lasted for 56 days during which water quality parameters pH, dissolved oxygen and temperature were monitored weekly. Fish were fed the experimental diets at 5% body weight twice daily between the hours of 8:00 – 9:00 and 16:00 – 17:00. The fish in each treatment were weighed every 2 weeks to determine quantity of feed to be fed.

Water quality

Water was changed every other day to maintain optimal quality. Parameters such as dissolved oxygen was maintained at an average level of 4.96 mg/l, temperature at 28.15ºC and pH at 6.80.

Proximate analysis

G. sepium leaves, experimental diets and fish carcasses after the experiment were analysed for their proximate composition according to the methods described by the Association of Official Analytical Chemists (AOAC 2005).

Growth performance and nutrient utilisation parameters of *Clarias gariepinus*

The growth performance and nutrient utilisation parameters of the *C. gariepinus* were evaluated by analysing total weight gain, average daily weight gain, relative growth rate, specific growth rate, daily feed intake, feed conversion ratio and protein efficiency ratio using the following formulae:

Weight gain (WG)
WG = Final weight of fish – initial weight of fish

Relative growth rate (RGR)

$$\text{RGR (\%)} = \frac{W_F * 100}{W_i}$$

Where:
W_F is final average weight of fish
W_i is initial average weight of fish

Specific growth rate (SGR) %

$$\text{SCR (\%/day)} = \frac{\log W_F - \log W_I}{N} * 100$$

Percentage survival

Survival rate =

$$\frac{\text{Initial number of fish} - \text{number of deaths}}{\text{Initial number of fish}} * 100$$

Feed conversion ratio (FCR)

$$\text{FCR} = \frac{\text{Total weight of diet fed}}{\text{Total weight of fish}}$$

Feed efficiency ratio (FER)

$$\text{FER} - \frac{\text{Weight gain}}{\text{Feed intake}} * 100$$

Protein efficiency ratio (PER)

$$\text{PER} = \frac{\text{Mean weight gain (g)}}{\text{Crude protein intake (g)}}$$

Haematological assessment

At the end of the feeding trial, fish blood samples were collected from the caudal peduncle using a pair of needle and syringe (2 mL). Blood samples were preserved in disodium salt of ethylenediaminetetraacetic Acid (EDTA) bottles as anticoagulant for analysis as described by (Joshi 2002). A standard haemocytometer was used in the counting of the red blood cells according to the method described by Blaxhall and Daisley

(1973) and by Svobodova et al. (1991). White blood cells were determined using the method described by Blaxhall and Daisley (1973). The packed cell volume was determined using the method described by Blaxhall and Daisley (1973) and by Dacie and Lewis (1977). The cyanmet-haemoglobin method was used in determining haemoglobin concentration according to the method described by Larsen and Snieszko (1961).

Statistical analysis

Data collected were subjected to one way analysis of variance using Statistical Package for Social Scientists (SPSS) version 20 and Duncan's multiple range test was used in separating the means in cases of significant differences. Statistical significance effect on the parameters measured was set at $P \leq 0.05$.

Results

Proximate analysis of *Gliricidia sepium* leaves

The proximate composition of *G. sepium* leaves used for the experiment is shown in Table 2.

Table 2: Proximate analysis of *Gliricidia sepium* leaves

	MC %	CP %	EE %	CF %	ASH %
GLM	72	21.88	3.35	11.77	7.89

MC = moisture content; CP = crude protein; EE = ether extract; CF = crude fibre
GLM = *Gliricidia sepium* leaf meal

Proximate composition of the experimental diets

The proximate analyses of the experimental diets are presented on Table 3. Crude protein ranged from 39.98% in the control (Diet 1) to 39.59% in Diet 5, and crude lipid ranged from 5.95% in Diet 1 to 7.77% in Diet 3. Diet 5 had the highest percentage of crude fibre, 8.97%, and the lowest was observed in Diet 1 6.15%. Ash ranged from 7.78% in Diet 1 to 9.98% in Diet 4. Moisture content ranged from 8.4% in the control (Diet 1) to 12.8% in Diet 2. Nitrogen free extract ranged from 23.78% in Diet 2 to 31.74 in Diet 1.

Table 3: Proximate composition (%) of the experimental feeds

Diet	1	2	3	4	5
Moisture content	8.4	12.8	8.8	7.4	9.2
Crude protein	39.98	39.89	39.75	39.67	39.59
Crude fibre	6.15	8.17	8.69	9.32	8.97
Crude lipid	5.95	7.15	7.77	6.14	7.48
Ash	7.78	8.17	9.73	9.98	8.78
Nitrogen free extract	31.74	23.78	25.22	27.49	25.98

Growth performance of *Clarias gariepinus* fingerlings fed with varying levels of *Gliricidia sepium* leaves

The growth performance of the fish fed the experimental diets is presented in Table 4. The mean weight gained in Diet 1 was highly significantly different from the other treatments ($P \leq 0.001$); the mean weight gain for Diet 1 was 17.98 g, none of the other diets recorded a mean weight gain of over 1.68 g. Average daily weight gains recorded were similar ($P > 0.05$) in Diets 2, 3, 4 and 5 but were highly significantly different ($P \leq 0.001$) from

Diet 1. Similar protein efficiency ratios (P > 0.05) were observed in Diets 2, 3, 4 and 5 with the highest being 0.20; Diet 1 was significantly different from the other diets with a ratio of 1.45. Feed fed in Diet 1 was significantly different from the other treatments, but Diets 2, 3, 4 and 5 were similar to each other (P > 0.05). The feed conversion ratios of fish fed Diets 2, 3, 4 and 5 were similar (P > 0.05) ranging between 14.06 and 19.09; Diet 1 was significantly different (P ≤ 0.001) with a value of 1.75. The feed efficiency ratios of *C. gariepinus* fed experimental Diets 2, 3, 4 and 5 were also similar (P > 0.05) with values ranging from 5.30 to 8.06; a significant difference was observed in Diet 1 with a ratio of 57.78. There were no significant differences (P > 0.05) in the specific growth rates of experimental Diets 2, 3, 4 and 5 with none above 0.39%; Diet 1 recorded a higher specific growth rate of 2.30%. The relative growth rates of the fish fed Diets 2, 3, 4 and 5 ranged between 14.89 and 24.41% (P > 0.05) with the value for Diet 1 significantly higher at 263.66% (P ≤ 0.001). The survival rate for fish on Diets 1, 3 and 4 was 100%; for Diets 2 and 5 the survival rate was significantly lower at 83.33%.

Table 4: Growth performance of *Clarias gariepinus* fingerlings fed with varying levels of *Gliricidia sepium* leaves

Diet	**1**	**2**	**3**	**4**	**5**	**SEM**	**P-value**
Initial weight (g)	6.82^{a}	6.84^{a}	6.89^{a}	6.87^{a}	6.83^{a}	0.09	0.99
Final weight (g)	24.80^{b}	7.99^{a}	8.57^{a}	8.08^{a}	7.84^{a}	1.79	0.00
Mean weight gain (g)	17.98^{b}	1.15^{a}	1.68^{a}	1.20^{a}	1.02^{a}	1.79	0.00
Average daily weight gain (g)	0.32^{b}	0.02^{a}	0.03^{a}	0.02^{a}	0.02^{a}	0.03	0.00
Specific growth rate (%)	2.30^{b}	0.29^{a}	0.39^{a}	0.28^{a}	0.25^{a}	0.23	0.00
Feed fed (g)	31.16^{c}	19.41^{a}	20.74^{b}	19.29^{a}	19.16^{a}	1.24	0.00
Feed conversion ratio	1.75^{a}	17.10^{b}	14.06^{b}	18.74^{b}	19.09^{b}	1.73	0.00
Protein efficiency ratio	1.45^{a}	0.15^{b}	0.20^{b}	0.14^{b}	0.13^{b}	0.14	0.00
Survival rate (%)	100.00^{b}	83.33^{a}	100.00^{b}	100.00^{b}	83.33^{a}	2.22	0.00

Means with different superscripts are significantly different from each other

Carcass composition of *Clarias gariepinus* fingerlings fed with varying levels of *Gliricidia sepium* leaves

Table 5 shows the proximate composition of *C. gariepinus* fed experimental diet. Moisture contents of fish were significantly different (P ≤ 0.05) for all the experimental diets with the highest recorded in Diet 4 (84.41%) and the lowest in Diet 1 (73.01%). Crude protein of *C. gariepinus* fed the experimental diet was observed to be significantly different (P ≤ 0.05) in all the experimental diets with highest crude protein observed in the flesh of fish in Diet 1 (15.22%) and lowest in Diet 4 (8.36%). Crude fibre in the fish was observed to be significantly different (P ≤ 0.05) in all the experimental treatments, with highest fibre recorded in Diet 4 (2.23%) and lowest in Diet 1 (1.05%). Crude lipid of *C. gariepinus* was significantly different (P ≤ 0.05) in all treatments with highest crude lipid observed in Diet 4 (2.36%) and lowest in Diet 5 (1.94%). The ash contents of fish fed the experimental diet were similar (P > 0.05) in Diets 3 and 5, but all the other diets were significantly different (P ≤ 0.05), with the values ranging from 1.86% (Diet 4) to 1.65% (Diet 1).

Table 5: Carcass composition (%) of *Clarias gariepinus* fingerlings fed with varying levels of *Gliricidia sepium* leaves

Diet	1	2	3	4	5	SEM	P-value
Moisture content	73.01^{a}	74.12^{b}	75.20^{c}	84.41^{e}	77.10^{d}	1.14	0.00
Crude protein	15.22^{e}	10.77^{d}	11.12^{c}	8.36^{a}	9.27^{b}	0.63	0.00
Crude fibre	1.05^{a}	1.12^{b}	1.14^{c}	2.23^{e}	2.09^{d}	0.14	0.00
Crude lipid	1.98^{b}	2.12^{c}	2.21^{d}	2.36^{e}	1.94^{a}	0.05	0.01
Ash	1.65^{a}	1.69^{b}	1.73^{c}	1.86^{d}	1.73^{c}	0.02	0.00
Nitrogen free extract	7.10^{e}	10.19^{d}	8.60^{c}	0.59^{a}	7.87^{b}	0.98	0.00

Means with different superscripts are significantly different from each other

Haematological analysis of *Clarias gariepinus* fingerlings fed varying levels of *Gliricidia sepium* leaves

The haematological parameters of *C. gariepinus* fingerlings fed the experimental diets are presented in Table 6. Packed cell volume varied significantly ($P \leq 0.05$) and ranged from 23.33 to 31.33%. White blood cell was significantly different ($P \leq 0.05$) in all diets with the control value of $2.37*10^9$/L being considerably lower than in the other diets where values ranged from 39.30 to $55.16*10^9$/L. There were significant differences ($P \leq 0.05$) in the haemoglobin concentrations observed for all diets. Red blood cell counts of *C. gariepinus* fingerlings were similar ($P > 0.05$) for Diets 4 and 5, but otherwise all diets were significantly different ($P \leq 0.05$); values ranged from 1.37 to $1.97*10^9$/L. Platelets observed showed that there were similarities ($P > 0.05$) in Diets 1, 2, 3, but these were significantly different ($P \leq 0.05$) from those which was observed in Diet 4 and 5. Neutrophils showed that there were similarities ($P > 0.05$) in Diets 2, 3, 4 and 5 but were significantly different ($P \leq 0.05$) from observed in the control diet. Lymphocyte showed no significant differences ($P > 0.05$) between Diets 2 and 3 and between Diets 4 and 5, but the Diet 1 value of 86.33% was significantly different ($P \leq 0.05$) from all the other diets.

Mean corpuscular volume was significantly different for all diets with the highest observed in Diet 4 (159.30 fL) and the lowest in Diet 2 (145.47 fL). Mean corpuscular haemoglobin of fish fed the experimental diets was significantly different in all treatments, with the highest control value of 57.67 pg considerably higher than those for other diets, which ranged from 28.87 to 31.40 pg. Mean corpuscular haemoglobin concentration was also much higher in the control diet; the other diets showed similar values, but the only difference that was not significant was between Diets 2 and 4.

Table 6: Haematology parameters of *Clarias gariepinus* fingerlings fed with varying levels of *Gliricidia sepium* leaves

Diet	1	2	3	4	5	SEM	P-value
PCV (%)	27.67^{c}	25.67^{bc}	31.33^{d}	25.33^{ab}	23.33^{a}	0.75	0.00
WBC (* 10^9/L)	2.37^{a}	42.40^{c}	55.16^{e}	39.30^{b}	48.80^{d}	4.93	0.00
Hb (g/L)	53.67^{d}	48.67^{c}	59.33^{e}	41.33^{b}	36.33^{a}	2.21	0.00
RBC (x 10^9/L)	1.77^{c}	1.57^{b}	1.97^{c}	1.37^{a}	1.38^{a}	0.06	0.00
Platelet (x 10^9/L)	6.00^{a}	5.67^{a}	5.33^{a}	7.67^{b}	8.33^{b}	0.34	0.00
Neutrophil (%)	7.67^{b}	1.33^{a}	1.67^{a}	1.33^{a}	1.00^{a}	0.68	0.00
Lymphocyte (%)	86.33^{a}	93.00^{b}	92.33^{b}	96.67^{c}	95.00^{c}	0.95	0.00
MCV (fL)	157.67^{c}	145.47^{a}	158.17^{d}	159.30^{e}	155.57^{b}	0.19	0.00
MCH (pg)	57.67^{e}	28.87^{a}	30.33^{c}	31.40^{d}	29.37^{b}	1.35	0.00
MCHC (g/L)	344.00^{d}	197.33^{c}	191.67^{b}	196.00^{c}	198.00^{a}	3.01	0.00

Means in the same row with different superscripts are significantly different from each other

PCV = packed cell volume; WBC = white blood cell count; Hb = haemoglobin; RBC = red blood cell count; MCV = mean corpuscular volume; MCH = mean corpuscular haemoglobin; MCHC = mean corpuscular haemoglobin concentration

Discussion

The nutrient composition of *G. sepium* in this study was similar to those reported by Aye and Adegun (2013). The crude protein content for Diet 1was higher than 10.94% reported by Ifut and Inyang (2007), which could be as a result of difference in season as reported by Panjaitan (1988). Ash content was in line with the findings of Animashahun et al. (2006) who reported higher values of ash for forages. The high level of ash content indicates the presence of mineral contents in the leaf, which are needed for the formation and proper functioning of blood and bones (Animashahun et al. 2006). The high level of fibre justifies the use of exogenous enzyme as suggested by Olopade et al. (2015). The proximate composition of the experimental diets was within the range of requirement of *C. gariepinus* fingerlings (Tiamiyu et al. 2015).

There were significant higher values of feed intake in the control diet, than for those fed the experimental diets with percentage inclusion of GLM, and this may be attributed to unpalatability of the feed or probably imposed by the presence of anti-nutritional agents found in GLM which include tannin, saponin, cyanide and possibly others, and this agrees with the reports of Odunsi et al. (2002) and Olopade et al. (2015). Compared to the control, there was a significant reduction in the growth parameters for GLM inclusion. This reduction could be attributed to the low acceptance of the feed due to the palatability problem. Sotolu and Faturoti (2009) reported that the growth of *C. gariepinus* decreased as the level of *Leucaena* seed meal inclusion increased in the diets. This was in contrast with the findings of Tiamiyu et al. (2015) who reported a significant increase in growth as the inclusion levels of *Leucaena* increased; this difference could be due to the processing technique applied which involved soaking and drying the leaves, hence reducing the anti-nutrient in *Leucaena* leaf meal. Afe and Omosowone (2019) discovered that *C. gariepinus* fed *Acacia auriculiformis* leaf supplemented diets had better weight gains than the control.

A high feed conversion ratio was recorded in all diets except for the control which shows poor nutrient utilisation for diets that contained varying levels of GLM. This could be as a result of the presence of the anti-nutrients (Lamidi 2014). Sotolu and Faturoti (2009) reported that nutrient utilisation by *C. gariepinus* decreased as *Leucaena* seed meal inclusion increased in the diets. Also, the low feed efficiency ratios observed in the diets with GLM inclusion could be attributed to the presence of anti-nutrients in the diets fed which made the feed unpalatable. The protein efficiency ratio was highest in fish fed 0% GLM (control) which differed statistically from values obtained at 25, 50, 75 and 100% GLM inclusions. This could also be linked with low feed intake and presence of anti-nutrients in the diets. Sotolu and Faturoti (2009) reported a decline in the protein efficiency ratio as concentrations of *Leucaena* Seed Meal increased in the diet of *C. gariepinus*. The observed differences in survival rates amongst treatments could be as a result of starvation caused by the unpalatability of the feed.

Carcass protein levels were reduced by the inclusion of GLM in the diets. This shows poor nutrient utilisation by the fish (Tsevis and Azzaydi 2000). The levels of crude fibre in the fish carcass compositions were low for all the diets and this had been said to be associated with effective utilisation of diets (Sotolu and Faturoti 2008).

The observed differences in the haematology of fish between the diets could be because of the residual effect of anti-nutritional factors present in the leaves after processing. Increased white blood cells with GLM inclusion is an indication that the fish were responding to the toxic effects of the diet fed (Jimoh et al. 2020). This was similar to the reports of Adeyemo (2005) and Osuigwe et al. (2005) that ascertained the reduction in values of haematological parameters such as packed cell volume, haemoglobin and red blood count were due to the presence of toxic substances in the diet of fish. In this study, red blood cell, haemoglobin and PCV were irregular across the treatments with the 50% level of inclusion of GLM appearing to have better values. This may be indicating a sign of adaptability of the fish to the diet at such inclusion level.

Water quality parameters influence the feed intake, growth, development, and psychology of fish (Kakwi and Audu 2016). For optimum growth of the fish, there has to be an appropriate water condition for the fish to survive; appropriate water parameters include temperature, pH, and dissolved oxygen (Afe and Omosomone 2019). There was a decrease in dissolved oxygen as the quantity of GLM increased in fish diets which could be attributed to the low acceptability of diets containing varying inclusion levels of GLM. Similar results were reported by Tolan and Sherif (2007), Musa et al. 2013, and Samkelisiwe and Ngonidzashe (2014) using different medicinal plants and additives in the laboratory culture of tropical fishes.

Conclusion

This study has shown that *G. sepium* leaves possess some potentials as a feedstuff, however, feeding the meal (processed by air drying) to *C. gariepinus* fingerlings has adverse effects on their growth performance and haematology profile. This may not make it a good candidate to either partially or totally replace soybean meal. There is need for further research on processing method(s) that will likely reduce the anti-nutritional factors in GLM and make it more useful as a feed ingredient for *C. gariepinus*.

Acknowledgement

The authors wish to thank the Department of Fisheries and Aquaculture, Federal University, Oye-Ekiti where this research was carried and the technical staff (laboratory) for the contributions to the success of the work.

References

Adejumo, J.O., and A.A. Ademosun. 1985. “Effects of Planting Distance, Cutting Frequency and Height on Dry Matter Yield and Nutritive Value of *Leucaena leucicephala* Sown Alone in Mixture *Panicum maximum*.” *Journal of Animal Production Research.* **5 (2)**:221.

Adeyemo, O.K. 2005. “Haematological and Histopathological Effects of Cassava Mill Effluent in *Clarias gariepinus*.” *African Journal of Biomedical Research* **8**:179–156.

Afe, O.E., and O.O. Omosowone. 2019. “Growth and Feed Utilization in *Clarias gariepinus* Fingerlings Fed on *Acacia auriculiformis* Leaf Supplemented Diets.” *International Journal of Fisheries and Aquaculture* **11 (3)**: 55– 61.

Akinrotimi, O.A., U.U. Gabriel, N.K. Owhonda, D.N. Onukwo, J.Y. Opara, P. Anyanwu, and P.T. Cliffe. 2007. “Formulating an Environmentally Friendly Fish Feed for Sustainable Aquaculture Development in Niger.” *Agricultural Journal* **2 (5)**: 606– 612.

Animashahun R.A, S.O. Omoikhoje, and A.M. Bamgbose. 2006**.** “Haematological and Biochemical Indices of Weaner Rabbits Fed Concentrate and *Syndrella nodiflora* Forage Supplement.” *Proceedings 11th Conference ASAN. I.AR&T, Ibadan, Nigeria* 29– 31.

AOAC (Association of Official Analytical Chemists). 2005. *Official Methods of Analysis of AOAC International*. 18th ed.

Asiedu, B., D. Malcolm, and S. Iddrisu. 2019. “Assessing the Economic Impact of Climate Change in the Small-Scale Aquaculture Industry of Ghana, West Africa.” *AAS Open Research*, *1*: 26. https://doi.org/10.12688/aasopenres.12911.2

Aye, P.A., and M.K. Adegun. 2013. “Chemical Composition and Some Functional Properties of Moringa Leucaena and Gliricidia Leaf Meals.” *Agriculture and Biology Journal of North America* ISSN

Print: 2151– 7517, ISSN Online: 2151– 7525, doi:10.5251/abjna.2013.4.1.71.77.

Blaxhall, P.C., and K.W. Daisley. 1973. "Routine Haematological Methods for Use with Fish Blood." *Journal of Fish Biology* **5 (6)**: 771– 781.

Chan, Y.C., N. Trana, S. Pethiyagodaa, C.C. Crissman, T.B. Sulserb, and M.J. Phillips. 2019. "Prospects and Challenges of Fish for Food Security in Africa." *Global Food Security* **20**:17–25. https://doi.org/10. 1016/ j.gfs.2018.12.002.

Dacie J.V., and S.M. Lewis. 1977. "Practical Haematology." *Churchill Livingstone. London* 73pp.

FAO. 2006. "State of World Aquaculture." *FAO Fisheries Technical Paper," No. 500. Food and Agriculture Organization, Rome* 134pp.

Ifut, O.J, and U.A. Inyang. 2007. "Effect of Brewers Spent Grains Supplementation on the of Guinea Grass (*Panicum maximum*) and Gliricidia (*Gliricidia sepium*) Foliages by West African Dwarf Goats." In *Proceedings of the 32nd Annual Conference of NSAP, Calabar, Nigeria* 204– 206.

Jimoh, J.O., A.M. Akinsorotan, J.B. Olasunkanmi, B.P. Omobepade, T.O. Babalola, and O. Fatoyinbo. 2020. "Effects of Prophylactics on Growth, and Hematology of African Catfish, *Clarias gariepinus* (Burchell, 1822) Fingerlings." *Egyptian Journal of Aquatic Biology and Fisheries* **24 (1)**: 471 – 481.

Joshi, P.K., M. Bose, and D. Harish. 2002. "Changes in Certain Haematological Parameters in a Siluroid Fish *Clarias batrachus* (Linn) Exposed to Cadmium Chloride." *Pollution Resources* **21 (2)**: 129– 131.

Kakwi, D.G., and B.S. Audu. 2016. **"**Effect of Partial Replacement of Soybean Meal with *Mucuna pruriens* Meal in the Diet of Common Carp, (*Cyrinus carpio* Linnaeus, 1785) Fingerlings." *Nigerian Journal of Fisheries and Aquaculture* **4 (2)**: 48–60.

Lamidi, A.A. 2014. "Dry Season Feeds and Feeding: A Threat to Sustainable Ruminant Animal Production in Nigeria." *Journal of Agriculture and Social Research* **14 (1)**: 17–30.

Larsen, H.N, and S.F. Snieszko. 1961. "Methods for Haematological Analysis with Fish Blood." *Journal of Fish Biology* **4 (4)**: 96– 101.

Musa, S.M., C.M. Aura, E.O. Ogello, R. Omondi, H. Charo-Karisa, and J.M. Munguti. 2013. **"**Haematological Response of African Catfish (*Clarias gariepinus,* Burchell 1822) Fingerlings Exposed to Different Concentrations of Tobacco (*Nicotiana tobaccum*) Leaf Dust." *ISRN Zoology* **2013**:1– 7.

Odunsi, A.A, M.O. Ogunleke, O.S. Alagbe, and T.O. Ajani. 2002. "Effect of Feeding *Gliricidia Sepium* Leaf Meal on the Performance and Egg Quality of Layers." *International Journal of Poultry Science* **1 (1)**: 26– 28.

Olopade, O.A., A.A. Lamidi, A. Akeem, and M.O. Ogungbesan. 2015. "Effect of *Gliricidia sepium* (Jacq) Leaf Meal Supplemented with Enzymes (Roxazyme® G2 and Maxigrain®) on Growth Performance of *Clarias gariepinus.*" *American Journal of Experimental Agriculture* **8 (3)**: 152– 158. Doi: 10.9734/AJEA/2015/15321.

Osuigwe, D.I., A.I. Obiekezie, and G.C. Onuoha. 2005. "Some Haematological Changes in Hybrid Catfish (*Heterobranchus longifilis* x *Clarias gariepinus*) Fed Different Dietary Levels of Raw and Boiled Jackbean (*Canavalia ensiformis*)." *African Journal of Biotechnology* **4 (9)**: 1017– 1021.

Panjaitan, M. 1988. "Nutritive Value of Tree Legumes Introduced in Indonesia." *Indonesian Agricultural Research and Development Journal* **10 (3)**:73– 80.

Samkelisiwe, N.H., and A.M. Ngonidzashe. 2014. "Replacing Fishmeal with Kikuyu Grass and Moringa Leaves: Effects on Growth, Protein Digestibility, Histological and Haematological Parameters in *Clarias* *gariepinus." Turkish Journal of Fisheries and Aquatic Sciences* **14**:795– 806.

Sandström, V., A. Chrysafi, M. Lamminen, M. Troell, M. Jalava, J. Piipponen, S. Siebert, O. van Hal, V. Virkki, and M. Kummu. 2022. "Food System By-Products Upcycled in Livestock and Aquaculture Feeds Can Increase Global Food Supply." *Nature Food* **3**:729– 740. https://doi.org /10.1038/s43016-022-00589-6

Sarkwa, F.O., O.R. Madibela, T, Adogla-Bessa, W.N. Mphinyane, J. Perkins, and E.C. Timpong-Jones. 2020. "Chemical Composition, *In Vitro* Dry Matter Digestibility and Gas Production of Four Browse Species and Their Combinations Used as Feed for Small Ruminants." *West African Journal of Applied Ecology* **28 (2)**: 106 – 117.

Sotolu, A.O., and E.O. Faturoti. 2008. "Digestibility and Nutritional Values of Differently Processed *Leucaena leucocephala* Seed Meals in the Diet of African Catfish (*Clarias gariepinus*)." *Middle East Journal of Scientific Research* **3**:190– 199.

Sotolu, A.O., and E.O. Faturoti. 2009. "Growth Performance and Haematology of *Clarias gariepinus* Fed Varying Inclusions of *Leucaena leucocephala* (Lam. de Wit) Seed Meals in the Diet of African Catfish (*Clarias gariepinus)*." *Revista Cientifica UDO Agrícola* **9 (4)**: 979– 985.

Speranza, B., A. Racioppo, A. Bevilacqua, V. Buzzo, P. Marigliano, E. Mocerino, Scognamiglio, C. Raffaela, M.R. Corbo, G. Scognamiglio, and M. Sinigaglia. 2021. "Innovative Preservation Methods Improving the Quality and Safety of Fish Products: Beneficial Effects and Limits". *Foods* **10 (11)**: 2854. https://doi.org/10.3390/foods10112854.

Svobodova, Z., D. Pravda, and J. Palackova. 1991. "Unified Methods of Haematological Examination of Fish." *Research Institute of Fish Culture and Hydrobiology,* Vodnany, Czech Republic 31pp.

Temesgen, G.G. 2004. "Utilization of Gliricidia Sepium Leaf Meal as Protein Source in Diets of Mozambique Tilapia, Oreochromis Mossambicus (Piscs: Cichlidae)." Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy.

Tiamiyu, L.O., V.T. Okomoda, and A.O. Agbo. 2015. "Nutritional Suitability of Leucaena Leaf Meal in the Diet of *Clarias Gariepinus." Journal of Fisheries Sciences.com E-ISSN 1307-234X, 9(2): 001-005 (2015)*

Tolan, A.E., and A.H. Sherif. 2007. "Effect of Some Growth Promoters on Growth Performance of Nile Tilapia (*Oreochromis niloticus*) Fingerlings." *Arabic Journal of Aquaculture* **2 (1)**: 89– 104.

Tsevis, A.A. and T.A. Azzaydi. 2000. "Effect of Feeding Regime on Selected Species of Fish." Article publication of FISON, Feb. 2000. Agora Site.