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Growth Performance of African Catfish *Clarias gariepinus* (Burchell, 1822*)* Fed with Varying Inclusion Levels of Watermelon (*Citrullus lanatus*) Bark

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Abstract

This study assessed the growth performance of *Clarias gariepinus* fed varying inclusion levels of watermelon (*Citrullus lanatus*) bark. A total of 120 samples with 0.75±0.209g mean weight and 3.9±0.31cm mean total length were acclimated in the laboratory for 14 days during which they were fed to satiation twice daily. Subsequently, they were randomly assigned to the five treatments diets with replicate in each case at 12 fish per treatment; T1 with 00%, T2 with 25%, T3 with 50%, T4 with 75%, and T5 with 100% levels of inclusion as a possible replacement for an equal weight of soybeans. The set-up ran for 12 weeks and the growth parameters (lengths and weight) were determined on weekly basis. Weight gain and specific growth rate were calculated. The physicochemical parameters of the test media were also determined on weekly basis according to standard methods. The data generated were subjected to a one-way analysis of variance. From the results: Treatments with 50% and 75% inclusion levels performed slightly better than the control in terms of weight gain. The highest weight obtained in T2 and T3 were 31.71±0.35g and 31.48±1.71g, respectively. Similarly, the optimum requirement of watermelon bark level in the formulation of practical diets for improved growth of *C. gariepinus* were 50% and 75% in terms of lengths. T_2 and T_3 had the highest total lengths with 19.05±0.35cm and 15.90±2.80cm, respectively; while the standard lengths in T_2 and T_3 were 13.50±0.35cm and 13.45±2.85, respectively. Hence, watermelon bark can replace the more expensive soybean thereby reducing the cost of production and curtailing environmental filth and disposal problems associated with watermelon bark waste in Nigeria.

INTRODUCTION

Every living organism especially fish and other aquatic organisms depends on food for survival and reproduction. There is constant struggle and competition for the few but readily available food supply and sources. This is why it has become pertinent to look out for the alternate source of food that is not only readily available but also facilitates the riding off of waste in the environment. Fish is an important resource for humans, especially as food, commercial, or subsistence, and has had a role in the culture through the ages serving as food to deities. African Catfish *(Clarias gariepinus*) are known to be omnivorous in their food habits (Anyanwu

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et al., 2012). Besides this, they are hardy and tolerant to a wide range of environmental conditions (Nwani *et al*., 2015). Feed is one of the major inputs in aquaculture production and fish feed technology has become one of the least developed sectors of aquaculture particularly in Africa and other developing countries of the world; and high cost of fish feed ingredients (maize and fish meal) has been observed as one of the problems militating against aquaculture development in Nigeria (Gabriel *et al.,* 2007). Aquaculture is the world's fastest-growing food production system, growing at 7% annually and fish products are among the most widely traded foods, with more than 37% (by volume) of world production traded internationally (FAO, 2009).

The efficiency of the various alternatives protein sources as a partial or complete replacement for fish meal has been individually evaluated in fish diets. Fishmeal has been replaced by single animal protein source such as maggot meal (Adewolu *et al*., 2010), poultry by-product meal (Türker *et al.,* 2005), poultry viscera meal (Usman *et al.,* 2007), and feather meal (Adewolu *et al*., 2010) among others. However, most of these single animal protein sources are unable to completely replace fishmeal (Adewolu *et al*., 2010) because of a lack in one or more of the essential amino acids (Wilson, 2002) that can lead to reduced growth gain and other growth parameters. Vegetable protein sources have been demonstrated to have a high potential for supplying fish with the required protein needed for their maximum productivity (Ndimele and Jimoh, 2011).

Knowledge of nutrition and practical feeding of fish is essential for successful aquaculture. To mitigate the effects of higher feed costs in fish culture, fish farmers have always sought to replace fish meal and fresh oil components of the diet. Fishing in both natural and artificial habitats is a major occupation in Nigeria. Fishing in plastic ponds is one of such artificial habitats. These forms of practices in fish farming require a supply of feed outside natural supply. To address the high cost of feed militating against profitable fish farming practices and competition for protein sources such as soya-bean alternate sources and supply are necessary. Watermelon (*Citrullus lanatus*) bark is usually wasted in our society. The crude protein content of watermelon bark values reported by other researchers is 17.25 and 17.05%, respectively (Agbabiaka *et al.,* 2011; Esonu *et al.,* 2006). This could serve as an alternative to the use of soya-bean and can eventually lead to a reduction in the high cost of feed for fish farmers. This is why this research was designed to address the possible alternative to the use of soya bean by using various inclusion levels of the watermelon bark as parts of the feeds for *C. gariepinus* in the laboratory to determine its effects on some growth parameters and feed conversion rate of the fish.

METHODOLOGY

Place and Time

This research was conducted in the Animal Biology Laboratory of Federal University of Technology, Bosso Campus, Minna, Nigeria from April to August 2019.

Research Materials

The following apparatuses and materials were directly involved in this research: Triple beam balance (model 700), Ten (10) plastic indoor aquaria tanks with 16 liters capacity (49×27×10 cm), 25 liters aquarium container, Borehole water, Measuring board graduated in centimeters, watermelon barks (disposed of by fruit vendors), sacks for drying in the sun and packaging, 120 samples of *C. gariepinus*. HANNA instruments Model: HI-98129 and HI-98130, respectively; Electrical conductivity meter (Lutron, CD 4303) for basic physio-chemical parameters.

Research Design

The experiment consists of five treatments, each with two replicates. Treatment 1 is the control, with treatments 2, 3, 4, and 5all exposed to equal light (12 hours) and darkness (12 hours) every day. Ten plastic indoor aquaria tanks with 16 liters capacity (49×27×10 cm) were all filled with water up to 10cm level. Each tank was stocked with 12 fingerlings of *C. gariepinus.* The *C. gariepinus* fingerlings were fed with different levels of the bark of watermelon inclusions. They were fed with the experimental diet for 12 weeks at the rate of 5% body weight per day.

Work Procedure

Samples Collection and Acclimatization

Four weeks old *C. gariepinus* fingerlings were bought from a private farm (Simple Farms Limited, Ibadan, Oyo State, Nigeria). The fingerlings were transported to the Department of Animal Biology laboratory of the Federal University of Technology, Bosso Campus, Minna, Niger State in an open ventilated 25 liters aquarium container with water. Minna is located between latitude $6^0 3$ and $6^0 45$ east of the equator. One hundred and twenty samples with 0.75±0.209g initial mean weight and 3.9±0.31cm mean total length were purchased. They were acclimated for fourteen (14) days and fed with a control diet (0% inclusion level) to satiation, 09.00 and 17.00 hours each day.

Collection and Processing of Watermelon Bark

The watermelon barks were collected from Bosso market fruit vendors, Minna, Niger State. They were sun-dried for 2 weeks, the dried watermelon was ground into a fine powder and analyzed for the proximate composition according to the procedure of APHA (2006).

Formulation of Fish Feed with Watermelon Bark

Proximate analysis of dietary ingredients was carried out. Then, five iso-caloric and nitrogenous diets were prepared; they contain 0%, 25%, 50%, 75%, and 100% inclusion levels of watermelon bark, to replace the equal weight of soybean, respectively, while the control diet (0%) contained no watermelon bark meal. A triple beam balance (model 700) was used in weighing the meals. The meal produced (watermelon bark) was mixed with other feeding ingredients to formulate five-iso-nitrogenous diets. The diets produced were passed through a pelleting machine die 2mm to produce pellets.

Thereafter, the pelleted feeds were sun-dried to crispy form for four (4) days to prevent the growth of molds and were packed in waterproof bags and labeled accordingly before storage at room temperature. The mean proximate composition of watermelon bark and levels of inclusion indicated that the crude protein content of the watermelon bark was 17.75%. Fiber constituted the highest component of watermelon bark; closely followed by fat (Table 1). The soybeans contents were gradually replaced until it gets to 0%. (Table 2).

Table 1. Mean proximate composition of watermelon bark.

Parameters	Percentage composition (%) of DMWB
Moisture	7.40
Fat	26.50
Crude protein	17.75
Fiber	36.8
Ash	2.00
Carbohydrate	9.55

DMWB: the dried matter of watermelon bark.

Table 2. Percentage Composition of Experimental Diet in Different Treatments (Watermelon Inclusion).

	Treatments				
Ingredients	L_o	L_{25}	L_{50}	L_{75}	L_{100}
Soybeans	40	30	20	10	0
Watermelon bark	0	10	20	30	40
Fish meal	15	15	15	15	15
Maize meal	31	31	31	31	31
Wheat middling	8	8	8	8	8
Vitamin premix	1	1	1	1	1
Mineral Premix	1	1	1	1	1
Vegetable oil	2	2	2	2	2
Bone meal	1.5	1.5	1.5	1.5	1.5
Salts	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

L_0 stands for the control, L_{25} stands for 25% watermelon inclusion, L_{50} stands for 50% watermelon inclusion, L_{75} stands for 75% watermelon inclusion, L_{100} stands for 100% watermelon inclusion.

Physicochemical Parameters of the Water Media

Water temperature and pH were measured weekly using HANNA instruments Model: HI-98129 and HI-98130, respectively. Dissolved Oxygen (DO) was measured using a test kit (HANNA instruments model: HI-3810). Unconsumed diets and fecal matters were siphoned off daily. The instruments were inserted into the sampled water and were allowed to stabilize for 2 minutes before taking the readings. Electrical conductivity was measured with a hand electric conductivity meter (Lutron, CD 4303) probe which was inserted into the sampled water from all the experimental tanks and allowed to stabilize for 2 minutes before the readings were taken. The readings were expressed in µS/cm.

Growth Parameters

Total Length and Standard Length of *C. gariepinus*

Total and standard lengths of *C. gariepinus* fingerlings in different treatments were determined according to Samuel and Balogun (2015) using a fish measuring board to the nearest 0.01cm every week. The standard length was determined by measuring the tip of the snout to the caudal lobe of the fish. The total length was measured from the tip of the snout to the tail end of the fish, usually measured with the lobes compressed along the midline.

The Weight of *C. gariepinus*

The weight of the fish was determined by randomly sampling 2 *C. gariepinus* fingerlings from each aquarium tank. This was determined by using a triple beam balance (model 700) graduated in grams weekly.

Weight Gain of *C. gariepinus*

The fish weight gain (WG) was calculated as the difference between the final weight of the fish at the end of the experiment and the initial weight gain in grams (Ahmad, 2012).

Specific Growth Rate (SGR)

The Specific Growth Rate (SGR) was calculated using the formula below (Samuel *et al.*, 2021):

$$SGR = \frac{(\ln W2 - \ln W1)}{(T2 - T1)} \times 100$$

Where:
SGR = specific growth rate (%/day)
W1 = initial weight (g)
W2 = final weight (g)
$T_1 - T_2$ = number of days

Data Analysis

Data obtained were pooled and subjected to one-way analysis of variance (ANOVA) at P≤0.05 level of significance. Duncan's multiple range test was used to separate the means where significant.

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RESULTS AND DISCUSSION

Growth Parameters of *C. gariepinus*

The total length of *C. gariepinus* fed with varying inclusion levels of watermelon bark for twelve weeks indicated that T_2 had the highest total length with 19.05±0.35cm followed by T_3 with a total length of 15.90±2.80cm, respectively. T_1 and T_4 had the least total length with 15.20±1.60cm and 13.30±0.10cm, respectively (Table 3).

Table 3. The total length of *Clarias gariepinus* fed with varying inclusion levels of watermelon bark for twelve weeks.

Treatments	Weeks					
	2	4	6	8	10	12
Control	7.77±0.60^b	12.70±1.30^e	13.85±0.65^d	16.95±0.95^e	17.35±2.65^e	19.8±0.50^e
T_1	6.70 ± 0.70^a	10.35±0.25^b	11.30±1.10^a	12.15±0.15^a	13.25±1.75^a	13.3 ± 0.10^a
T_2	10.70±0.50^e	11.60±2.50^d	12.10±0.85^c	15.00±0.50^d	15.90±0.60^d	19.05±0.35^d
T_3	10.00±0.40^d	11.50±1.00^c	11.70±1.20^b	14.80± 0.10^c	15.10±1.40^b	15.90±2.80^c
T_4	8.50±0.55^c	10.05±0.45^a	11.30±0.60^a	14.75±2.65^b	15.35±1.15^c	15.20±1.60^b

T1-T4 represents the various treatments. Values with different superscripts across the columns are significantly different at P≤0.05 level of significance.

Likewise, T_2 had the highest standard length with 13.50±0.35cm closely followed by T_3 and T_4 with 13.45±2.85 and 13.40±2.10cm, respectively. T_1 had the least standard length with 10.75±0.35cm. (Table 4).

Table 4. Standard Length of *C. gariepinus* fed with varying inclusion levels of watermelon bark for twelve weeks.

Treatments	Weeks					
	2	4	6	8	10	12
Control	6.75±0.55^b	11.40±1.80^e	11.95±0.85^e	15.00±1.30^e	15.00±0.30^e	15.85±0.35^e
T_1	6.45±0.25^a	9.70± 0.10^b	9.70±0.90^a	10.50±0.10^a	10.70±0.90^a	10.75±0.35^a
T_2	9.50±0.10^d	10.50±0.40^d	11.75±0.75^d	12.85±2.65^d	13.95±0.95^d	13.50±0.35^d
T_3	7.50±0.30^c	9.85±2.05^c	10.35±0.85^c	12.60±0.10^c	13.10±1.30^c	13.45±2.85^c
T_4	7.50±0.60^c	8.80 ± 1.00^a	10.25±0.45^b	11.45±0.25^b	13.05±0.45^b	13.40±2.10^b

T1-T4 represents the various treatments. Values with different superscripts across the columns are significantly different at P≤0.05 level of significance.

Growth performance of *C. gariepinus* fingerlings fed with different feed types revealed the initial mean weight of fingerlings used in each treatment as T_1 = 3.64±0.64g, T_2 = 6.64±0.39g, T_3 = 3.80±0.29g and T_4 = 3.81±0.32g, respectively (Table 5).

Table 5. Weight of *C. gariepinus* fed with varying inclusion levels of watermelon bark for twelve weeks.

Treatments	Weeks					
	2	4	6	8	10	12
Control	4.32±0.65^c	9.14±0.25^d	12.09±1.15^d	18.69±0.34^b	27.99±0.89^e	31.32±0.60^c
T_1	3.64±0.64^a	5.51±0.41^a	08.18±0.50^a	15.19±0.80^a	19.90±1.13^a	20.57±1.43^a
T_2	4.64±0.39^d	9.95±0.57^e	12.16±0.20^e	22.37±1.91^e	23.19±1.18^d	31.71±0.35^e
T_3	3.80±0.29^b	8.31±0.28^b	10.80±0.32^c	22.15±0.45^d	22.93±0.39^c	31.48±1.71^d
T_4	3.81±0.32^b	8.57±0.23^c	9.62±0.69^b	21.56±0.85^c	21.01±1.01^b	24.24±2.81^b

T1-T4 represents the various treatments. Values with different superscripts across the columns are significantly different at P≤0.05 level of significance.

The specific growth rate was calculated and the highest was obtained in T_3 with 2.517±1.00%/day; and T_1 and T_2 showed the final mean weight of 20.57 ±

1.43 g and 31.71 ± 0.35 g, respectively while 31.48±1.71g and 24.24±2.81g were obtained in T_3 and T_4. On average, T_2 samples fared better than T_3, T_1, and T_4 samples (Table 6).

Table 6. Growth parameters of *C. gariepinus* fed with varying inclusions levels of watermelon bark for twelve weeks represented as Mean ± Standard Error.

Parameters	Control	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Initial weight (g)	4.32±0.65	3.64±0.64	4.64±0.39	3.80±0.29	3.81±0.32
Final weight (g)	31.32±0.60	20.57±1.43	31.71±0.35	31.48±1.71	24.24±2.81
Weight gain (g)	27.0±0.05	16.93±0.79	27.07±0.04	27.68±1.42	20.43±2.49
Specific growth rate (%/day)	2.358±0.63	2.062±1.04	2.288±0.37	2.517±1.00	2.203±1.57

The Physicochemical Parameters of the Test Media

The monitored physicochemical parameters were not affected by different diets during twelve weeks in the feeding trials. The recorded mean values of all these parameters were within the acceptable limits for fish growth and survival (Table 7).

Table 7. Physicochemical parameter of the test media of *C. gariepinus* fed with varying inclusion levels of watermelon bark for twelve weeks.

Parameters	Control	T1	T2	T3	T4
pH	7.25 ± 1.24^a	8.33 ± 1.08^b	7.23 ± 1.23^a	7.25 ± 1.2.4^a	7.25 ± 1.24^a
Dissolved Oxygen(mg/L)	3.92 ± 0.60^c	3.58 ± 0.54^a	4.43 ± 030^d	3.70 ± 0.45^b	3.68 ± 0.61^b
Electrical Conductivity(µS/cm)	0.51 ± 0.40^a	0.48 ± 0.38^a	0.54 ± 0.34^b	0.52 ± 0.04^a	0.51 ± 0.04^a
Temperature(̊C)	27.9 ± 0.09^a	28.07 ± 0.15^b	28.03 ± 0.18^a	28.13 ± 0.27^c	28.05 ± 0.08^b

Mean values with different superscripts across the rows are significantly different (P≤0.05).

The crude protein content of watermelon bark recorded in this study (17.75%) is slightly higher than values of 17.25 and 17.05% previously reported by Agbabiaka *et al.* (2011) and Esonu *et al.* (2006), respectively. This may be attributed to vegetation diversity and the season of the year the samples were collected. Lower values of the rind and seeds of watermelon (7.04±0.00 and 21.46±0.04) and energy values of 360.59±0.01 and 573.58±0.30 were, however, reported by Egbuonu (2015). He also posited that the flour of watermelon seed followed by the rind has nutrient, energy, storage, and industrial potential which could improve their utilization thereby preventing possible adverse environmental effects. Watermelon bark is probably made up of high carbohydrate content in comparison with other components. The carbohydrate contents in both watermelon peel and seeds were reported by Zubairu *et al.* (2018) as 59.03% and 19.45%, respectively.

There were distinct variations in growth patterns of fish fed varying inclusion levels which can be attributed to the extent and effects of the utilization of the diet. The weight gain in the control, T2, and T3 were nearly at par (but higher in T3 than T2 and the Control) indicating how the samples were able to effectively utilize the 50% and 75% inclusion levels. These inclusion levels performed fairy better than the control despite the lower crude protein content of the watermelon bark (17.75%) when compared to soybean which has been reported to constitute 39.24% (Bayero *et al.*, 2019). This is probably because as the duration of the experiment increased with the increasing age of the fish there may have been a greater ability to switch from high protein content to carbohydrate which led to gain in weight and other growth parameters. This is also likely that the fish samples adapted to the news feed over time.

These levels of inclusions could probably replace the soybean in the feed diet formulation of *C. gariepinus* thereby reducing a load of waste while relieving the pressure of competition on soybeans for other purposes. This could also be attributed to the fact that *C. gariepinus* are known to be omnivorous in their food habits (Anyanwu *et al*., 2012). In addition, *C. gariepinus* is known to be hardy and capable of surviving adverse environmental conditions. Similar findings by Tiamiyu *et al*. (2014) indicated 10% success in the inclusion of raw seeds of watermelon in the diet of *Cyprinus carpio* fingerling's meal. The findings from this research conform with Oladipupo and Salami (2020) when they reported that 2.0g/kg inclusion of watermelon peal in the meal of *C. gariepinus* gave the best growth performance and led to improved hematological parameters.

The improvement in the specific growth rate and increased weight gain obtained in this research in the 50 and 75% inclusion levels respectively are also in conformity with the findings of Tiamiyu *et al*. (2015) when they reported that the mean weight gain, specific growth rate, protein efficiency ratio was highest in the 50% inclusion level of watermelon seed. Furthermore, Iheanacho *et al*. (2018) reported that their highest treatment (100%) inclusion level of melon seed peel had the best growth performance (better than the control) when they evaluated the effects of different inclusion levels of *Citrullus lanatus* seed peel in the diet of *Oreochromis niloticus*. On the other hand, Jimoh *et al*. (2018) recorded no significant differences in the weight gain and specific growth rate when *Oreochromis niloticus* was subjected to varying inclusion levels of watermelon seeds. This is probably due to differences in species.

Likewise, the specific growth rate of the 100% inclusion level in this research decreased. This is probably because the fish can no longer tolerate the toxic level and the anti-nutrient agents in the watermelon bark. In line with this, Fakunle *et al*. (2013) reported that toxic components or anti-nutritional factors in most agricultural by-products may irritate the digestive tract which is capable of decreasing feed intake and growth. This is also in agreement with the findings of Solomon *et al*. (2017) who found that the specific growth decreased with increasing substitution level of the brewer's yeast in *C. gariepinus*.

The morphological differentiation measured as lengths varied with varying inclusion levels of the watermelon bark. The standard length also indicated that at the 50% and 75% levels of inclusion the fishes fared better than the other treatments except for the control. Similar trends were also exhibited in the measured total lengths of the samples. This probably gives credence to the fact that the fishes were able to effectively utilize these inclusion levels to their advantage. In line with this, Nwanevu *et al*. (2018) reported how commercial feed coated with watermelon syrup booster recorded the best performance in the mean weight and gain, mean length and gain, and related growth parameters.

The physicochemical parameters obtained from the routine check-in this research are within permissible limits, and the various changes in the growth parameters from the various inclusion levels are probably not altered by the environmental conditions of the test media. For instance, the optimal dissolved oxygen concentration for the growth of eggs and juveniles of African catfish (*C. gariepinus*) is 9 mg/L, while adults would survive in water of at least 3mg/L dissolved oxygen (FAO, 2013). Also, the ranges of values obtained are within the range for optimal fish production (Boyd and Lickotoper, 2014).

CONCLUSION

The study has shown that the watermelon bark diet can be tolerated by African catfish. Hence, can replace the more expensive soybean especially at 50% and 75% inclusion levels in terms of weight gain, thereby reducing the cost of production and curtailing environmental filth and disposal problems associated with watermelon bark waste in Nigeria. The results also revealed that the optimum requirement of watermelon bark level in the formulation of practical diets for improved growth of *C. gariepinus* were 50% and 75% in terms of length.

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REFERENCES

Adewolu, M.A., Ikenweiwe, N.B. and Mulero, S.M., 2010. Evaluation of an animal protein mixture as a replacement for fishmeal in practical diets for fingerlings of *Clarias gariepinus* (Burchell, 1822). *Israeli Journal of Aquaculture-Bamidgeh*, *62*(4), pp.237-244. https://ija.scholasticahq.com/issue/2832

Agbabiaka, L.A., Amadi, S.A., Oyinloye, G.O.M., Adedokun, I.I. and Ekeocha, C.A., 2011. Growth Response of African Catfish (*Clarias gariepinus,* Burchell 1822) to Dried Rumen as a Dietary Supplement. *Pakistan Journal Nutrition*, *10*(6), pp.564-567. https://dx.doi.org/10.3923/pjn.2011.564.567

Ahmad, Z., 2012. Toxicity bioassay and effects of sub-lethal exposure of malathion on biochemical composition and haematological parameters of *Clarias gariepinus*. *African Journal of Biotechnology*, *11*(34), pp.8578-8585. https://doi.org/10.5897/AJB12.226

Anyanwu, D.C., Umeh, O.I., Ugo, C.K., Maduka, B.C. and Mbachu, M.U., 2012. Nutrient utilization and growth of catfish *(Clarias gariepinus*) fed dietary levels of cassava leaf meal. *Pakistan Journal Nutrition*, *11*(11), pp.1037-1040. https://dx.doi.org/10.3923/pjn.2012.1037.1040

APHA (American Public Health Association), 2006. *Standard methods for the examination of water and waste water 14th edition*. Washington DC., p.107.

Bayero, A.S., Datti, Y., Abdulhadi, M., Yahya, A.T., Salihu, I., Lado, U.A., Nura, T. and Imrana, B., 2019. Proximate composition and the mineral contents of soy beans (*Glycine max*) available in Kano State, Nigeria. *ChemSearch Journal*, *10*(2), pp.62-65. https://www.ajol.info/index.php/csj/article/view/192131

Boyd, C.E. and Lickotoper, F.I., 2014. *Water quality in pond for aquaculture.* Alabama Agriculture Experimenta station, Auburn University Alabama, p.30.

Egbuonu, A.C.C., 2015. Comparative investigation of the proximate and functional properties of watermelon (*Citrullus lanatus*) rind and seed. *Research Journal of Environmental Toxicology*, *9*(3), pp.160-167. http://dx.doi.org/10.3923/rjet.2015.160.167

Esonu, B.O., Ogbonna, U.D., Anyanwu, G.A., Emenalom, O.O., Uchegbu, M.C., Etuk, E.B. and Udedibie, A.B.I., 2006. Evaluation of performance, organ characteristics and economic analysis of broiler finisher fed dried rumen digesta. *International Journal of Poultry Science*, *5*(12), pp.1116-1118. https://dx.doi.org/10.3923/ijps.2006.1116.1118

Fakunle, J.O., Alatise, S.P., Effiong, B.N. and Tiamiyu, K., 2013. Effects of replacing soybean meal with graded levels of boiled Jatropha kernel meal in diets of *Clarias gariepinus* fingerlings. *Bulletin of Environment, Pharmacology and Life Science*, *2*(9), pp.112-117. http://www.bepls.com/aug_2013.html

FAO (Food and Agricultural Organization), 2009. The State of World Fisheries and Aquaculture. *Annual conference In Rome. Updated in January 2010*, pp.19-20.

FAO (Food and Agricultural Organization), 2013. *Improving pond water quality. Training Series for Aquaculture*. https://www.fao.or g/fishery/docs/CDrom/FAO_Training/FAO_Training/General/x6709e/Index.htm

Gabriel, U.U., Akinrotimi, O.A., Bekibele, D.O., Onunkwo, D.N. and Anyanwu, P.E., 2007. Locally produced fish feed: potential for aquaculture development in sub-Saharan Africa. *African Journal of Agricultural Research*, *2*(7), pp.287-295. https://doi.org/10.5897/AJAR.9000470

Iheanacho, S.C., Ikwo, T.N., Igweze, N.O., Chukwuidha, C., Ogueji, E.O. and Onyeneke, R., 2018. Effect of different inclusion of melon seed (*Citrullus lanatus*) peel on growth, hematology and histology of *Oreochromis niloticus*. *Turkish Journal of Fisheries and Aquatic sciences*, *18*(3), pp.377-384. DOI:10. 4914/1303-2712-v18_3_03

Jimoh, W.A., Shittu, M.O., Abdulsalami, S.A., Okemakin, F.Y. and Ayeloja, A.A., 2018. Effect of replacing soybean meal with water melon (*Citrullus lanatus*) seed meal on the growth, feed utilization and body composition of Nile Tilapia (*Oreochromis niloticus*). *Nigerian Journal of Animal Production*, *45*(2), pp.59-66. http://dx.doi.org/10.51791/njap.v45i2.500

Ndimele, P.E. and Jimoh, A.A., 2011. Water hyacinth (*Eichhornia crassipes* (Mart.) Solms.) in Phytoremediation of Heavy Metal Polluted Water of Ologe Lagoon, Lagos, Nigeria. *Research Journal of Environmental Sciences*, *5*(5), pp.424-433. https://dx.doi.org/10.3923/rjes.2011.424.433

Nwanevu, E.C., Sokari, G.M., Isitor, G.N., Orlu, E.E., Ogolo, S.G. and Ebere, N., 2018. Effect of locally formulated watermelon and *Moringa* syrup booster on the growth performance of *Heterobranchus bidorsalis* fingerlings. *Journal of Applied Life Sciences International*, *21*(4), pp.1-12. http://dx.doi.org/10.9734/jalsi/2019/v21i430109

Nwani, C.D., Ifo, C.T., Nwamba, H.O., Ejere, V.C., Onyishi, G.C., Oluah, S.N., Ikwuagwu, E.O. and Odo, G.E., 2015. Oxidative stress and biochemical responses in the tissues of African Catfish *Clarias gariepinus* juvenile following exposure to primextra herbicide. *Drug and Chemistry Toxicology, 38*(3), pp.278-285. https://doi.org/10.3109/01480545.2014.947503

Oladipupo, T.M. and Salami, S.R., 2020. Effects of dietary inclusion levels of water melon (*Citrullus lanatus*) peel meal on growth and haematological parameters of *Clarias gariepinus* juveniles. *International Journal of Fisheries and Aquatic Studies*, *8*(3), pp.537-541. https://www.fisheriesjournal.com/archives/2020/vol8issue3/PartG/8-3-32-853.pdf

Samuel, P.O. and Balogun, J.K., 2015. Some aspects of the biology of *Hemisynodontis membranaceus* (Geoffrey St- Hilaire, 1809) in Zaria, Kaduna State, Nigeria. *Sci-Afric Journal of Scientific Issues, Research and Essays, 3*(5), pp.717-725. http://repository.futminna.edu.ng:8080/jspui/handle/123456789/7309

Samuel, P.O., Arimoro, F.O., Ayanwale, A.V. and Mohammad, H.L., 2021. Assessment of the Ameliorative Roles of Vitamins A, C and E on morphometric parameters of *Clarias gariepinus* (Burchell, 1822) Fingerlings Exposed to Cadmium Chloride. *Journal of Agriculture and Aquaculture*, *3*(1), pp.1-15. https://doi.org/10.5281/zenodo.4575180

Solomon, S.G., Ataguba, G.A. and Itodo, G.E., 2017. Performance of *Clarias gariepinus* fed dried Brewer’s yeast (*Saccharomyces cerevisiae*) slurry in replacement for soybean meal. *Journal of Nutrition and Metabolism*, *1*(1), pp.1-9. https://doi.org/10.1155/2017/8936060

Tiamiyu, L.O., Ayuba, V.O., Okomoda, V.T. and Umar, S., 2014. Effect of various levels of *Citrullus lanatus* seedmeal diets on growth performance of *Cyprinus carpio* fingerlings. *Jordan Journal of Biological Sciences*, *7*(4), pp.269-274. http://dx.doi.org/10.12816/0008250

Tiamiyu, L.O., Okomoda, V.T. and Agbese, V.E., 2015. Growth performance of *Clarias gariepinus* fingerlings fed *Citrullus lanatus* seed meal as a replacement for soybean meal. *Journal of Aquaculture Engineering and Fisheries Research*, *1*(1), pp.49-56. https://doi.org/10.3153/JAEFR 15005

Türker, A., Yigit, M., Ergun, S., Karaali, B. and Erteken, A., 2005. Potential of poultry byproduct meal as a substitute for fishmeal in diets for Black Seaturbot *Scophthalmus maeoticus*: Growth and nutrient utilization in winter. Israel. *Journal Aquaculture Bamidgeh*, *57*, pp.49-61. https://doi.org/10.46989/001c. 20392

Usman, R., Palingi, N.N. and Ahmad, T., 2007. Utilization of local feed ingredients in tiger grouper grow out moist diets. *Aquaculture Asia Magazine*, pp.33-36.

Wilson, R.P., 2002. *Amino acids and proteins*. In: Hardy Jehw (ed) Fish nutrition, 3rd edition. Academic Press, San Diego, pp.143-179.

Zubairu, A., Gimba, A.S.B., Mamza, W.J. and Highina, B.K., 2018. Proximate analysis of dry water melon (*Citrullus lanatus*) rind and seed powder. *Journal of Scientific and Engineering research*, *5*(3), pp.473-478. http://jsaer.com/download/vo l-5-iss-3-2018/JSAER2018-05-03-4 73-478.pdf