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Clarias gariepinus Growth Performance And Water Quality Assessment On *Bambusa vulgaris* Substituted Fish Feed Formulation

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ABSTRACT

The rising cost and limited sustainability of conventional fish feed ingredients pose significant challenges to *Clarias gariepinus* (African catfish) aquaculture. This study investigated the potential of using processed *Bambusa vulgaris* (Bamboo leaf/shoot) meal as a partial substitute for a conventional feed component (e.g., maize or soybean meal) to assess its impact on growth performance and water quality parameters. Juvenile *C. gariepinus* (315) with an initial mean weight of 17.21±0.01 g to 36.44±0.05 g were randomly distributed into seven (7) tanks (triplicates) and fed four isonitrogenous diets (19.1 % Crude Protein) where *B. vulgaris* meal substituted the reference ingredient at graded levels: 0% (Control), 10% (D1), 20% (D2), 40% (D3), and 80% (D4) for a feeding trial period of 12 weeks. Growth indices, including Mean Weight Gain (MWG), Standard Length (SL), and Total Length (TL), were monitored bi-weekly. Water quality parameters pH, Dissolved Oxygen (DO), Ammonia (NH_3) and Nitrite (NO_2) were measured bi-weekly. Results showed that fish fed the 10 % *B. vulgaris* inclusion diet exhibited the best growth performance, with the highest MWG 254.25±0.35 g, Standard Length of 84.32±0.03 cm and Total Length of 88 cm and the lowest MWG of the BVLM in D4 with 148.1±0.14 g all on day 84. Significant differences ($p < 0.05$) were observed across most growth parameters among the dietary groups. Furthermore, all monitored water quality parameters remained within the optimal range for *C. gariepinus* across all treatments (e.g., DO range: 1±0 to 5±0 mg/L; Ammonia < 0.05 mg/L (or ppm) indicating that the inclusion of *B. vulgaris* meal up to 80% did not affect the culture environment across all groups and the period of culture. In conclusion, the findings suggest that processed *Bambusa vulgaris* meal is a viable, cost-effective, and sustainable alternative ingredient in the diet of *Clarias gariepinus* at an optimal inclusion level of 10%, promoting good growth performance without compromising critical water quality.

Keywords: *Bambusa vulgaris* leave meal (BVLM); Mean Weight Gains; *Clarias gariepinus*

INTRODUCTION

Fish is a notable source of animal protein for human consumption, most especially in countries where animal protein intake is low such as the third world countries (Tacon and Metian, 2008). However, the global demand for fish has exceeded the natural supply, leading to overexploitation and depletion of fish stocks (FAO, 2018). Aquaculture, or the farming of aquatic organisms, has emerged as a viable alternative to meet the increasing demand for fish (Hasan and Tan, 2020). However, one of the major challenges facing aquaculture is the provision of adequate and sustainable fish feed for cultured fish (Dorothy *et al*., 2018a). Fish feed is composed of various ingredients that provide essential nutrients for fish growth and health (Foild *et al.*, 2001). These ingredients include protein sources (such as fish meal, soybean meal, etc.), carbohydrate sources (such as corn, wheat, etc.), lipid sources (such as fish oil, vegetable oil, etc.), vitamins, minerals, and additives (Sharma *et al*., 2022; Dorothy *et al*., 2018b; Egbuna *et al*., 2018). However, some of these ingredients are expensive, scarce, or have negative environmental impacts. Therefore, there is a need to find alternative or complementary ingredients that are cheap, available, and eco-friendly (FAO, 2018).

One of the potential sources of alternative or complementary ingredients for fish feed production as plant material with high nutritional and phytochemical value. Plants are abundant, renewable, and biodegradable resources that can provide various nutrients and bioactive compounds for fish.

Plant materials can be used as whole plants or as extracts or fractions that contain specific compounds of interest. Some examples of plant materials that have been used or studied as fish feed ingredients include legumes, cereals, oilseeds, fruits, vegetables, herbs, spices, seaweeds, etc. (Hasan and Tan, 2020; Simple *et al,* 2021 a,b).

Bambusa vulgaris, a species of bamboo commonly known as the common bamboo, is increasingly recognized for its significant potential in sustainable development. Bamboo, including B. vulgaris, is a versatile and fast-growing plant that offers numerous ecological and economic benefits. Recent research has highlighted its contributions to renewable resources, carbon sequestration, climate change mitigation, and its role in the development of green buildings and eco-friendly materials. This paper reviews the literature from 2014 onward on the various aspects of *Bambusa vulgaris* in promoting sustainable development.

Traditionally, B*ambusa vulgaris* has been employed for its medicinal properties in various folk medicine practices, particularly in Asia. The plant is used in multiple forms, including the leaves, roots, and stems, for the treatment of various ailments. In traditional Chinese medicine (TCM), the juice from the stem is considered effective for treating conditions like fever, cough, and inflammation (Liu et al., 2020). The root of *Bambusa vulgaris* has been used as a diuretic and a remedy for dysentery (Chung *et al*., 2015). Additionally, the bamboo's high silica content has led to its use in promoting skin health and enhancing bone strength in traditional healing systems
(Almeida *et al*., 2017).

According to Turan *et al*. (2015), water quality is fundamental to the health and productivity of fish in aquaculture systems. It directly influences fish metabolism, growth, behavior, and disease resistance. As a result, maintaining optimal water quality is critical to successful catfish farming. The primary water quality parameters that need to be monitored include dissolved oxygen (DO), temperature, pH, ammonia, nitrite, nitrate levels, salinity, and turbidity.

Dissolved Oxygen:

Dissolved Oxygen is one of the most critical parameters in aquaculture. Fish, including catfish, rely on oxygen for cellular respiration, and low oxygen levels can lead to reduced growth rates, increased stress, and even mortality. Regular monitoring of DO levels is necessary to ensure that oxygen concentrations remain within optimal ranges for catfish, which typically require oxygen levels between 5-8 mg/L (Yuan *et al*., 2018). Water temperature affects metabolic rates, growth, and immune function in fish. Catfish are warm water species, and their optimal temperature range for growth is typically between 24°C and 30°C (Ali *et al.*, 2020). Temperature fluctuations outside of this range can result in reduced growth rates, lower feed efficiency, and increased susceptibility to diseases.

The pH level:

pH of water affects the solubility and availability of nutrients and minerals, as well as the fish's ability to assimilate oxygen. The ideal pH range for catfish is between 6.5 and 8.5 (El-Sayed *et al*, 2014). Outside of this range, physiological stress can occur, affecting fish growth and health. Alkalinity plays a role in buffering pH and maintaining a stable environment for the fish.

Ammonia and Nitrite:

Ammonia are toxic to fish, even at low concentrations. Ammonia, primarily from fish excretion, is converted to nitrite by nitrifying bacteria, which is also harmful to catfish. Elevated levels of these compounds are often linked to poor water quality management (Boyd, 2015). Nitrate is while less toxic than ammonia and nitrite, can accumulate and become problematic in closed systems. Thus, regular testing of these parameters is essential for maintaining a healthy environment for catfish. Salinity affects osmotic regulation and general fish health, particularly in species like catfish, which are generally freshwater organisms. While catfish can tolerate low levels of salinity, it should be monitored to avoid undue stress (Kumari *et al*., 2017). Turbidity, caused by suspended particles in the water, can reduce light penetration and affect photosynthesis in aquatic plants, as well as clog gills in fish, leading to stress or respiratory problems.

Water quality testing in catfish farming is essential for several reasons. First, it ensures that the aquatic environment supports the health and well-being of the fish. Suboptimal water conditions can lead to stress, disease outbreaks, and poor growth performance, ultimately reducing productivity and profitability (Turan, 2015). Second, water quality monitoring helps in diagnosing potential issues before they become severe, allowing for corrective actions to be taken. Third, water quality tests can help ensure compliance with environmental regulations, especially in intensive aquaculture operations where the risk of pollution is higher.

Proper water management practices, including regular testing and adjustments, help optimize fish growth and minimize the environmental footprint of aquaculture operations. By maintaining stable and favorable water conditions, farmers can achieve higher feed conversion ratios (FCR) and improve overall production efficiency (Boyd and Tucker, 2014).

Fish feed is a critical component of modern aquaculture, directly influencing fish growth, health, and overall productivity. As global demand for aquaculture products continues to rise, the development of efficient, sustainable, and nutritionally balanced fish feed has become an essential area of research and innovation. Over the past decade, advancements in fish feed have addressed the challenges posed by fish nutrition, environmental sustainability, and the cost of feed ingredients. This paper provides an extensive overview of fish feed, focusing on its evolution, composition, ingredients, sustainability concerns, and the role of innovation in addressing the needs of a growing aquaculture industry.

Fish feed serves as the primary source of nutrition for farmed fish, providing the necessary energy and nutrients for growth, reproduction, and disease resistance. In aquaculture, feed typically accounts for more than 50% of the total production cost, making it a major factor in the economic viability of fish farming (Tacon *et al*., 2020). As such, understanding fish feed composition, formulation, and sourcing is critical to optimizing aquaculture productivity while minimizing environmental impacts. In traditional aquaculture systems, the goal of feeding was simple: provide enough food to maintain fish health and ensure acceptable growth rates. However, with the growth of the global aquaculture industry, there has been an increased emphasis on formulating feeds that are not only nutritionally balanced but also economically feasible, sustainable, and environmentally responsible (Fry *et al*., 2020)

African Catfish, belonging to the family *Ictaluridae* (in North America) or *Siluridae* (in Europe and Asia), represent an economically significant group of freshwater fish. They are particularly valued for their high commercial demand, nutritional benefits, and adaptability in aquaculture systems. Over the past decade, the study of catfish has expanded to include their biology, cultivation methods, and the environmental and economic impacts of their farming.

MATERIALS AND METHODS

All the reagents and chemicals used in the study were either B.P grade or U.S.P grade and were procured from the University of Port Harcourt Teaching Hospitals Complex Port Harcourt. All the reagents and chemicals used were of analytical grade and were obtained from either Sigma or BDH and Randox Laboratory Limited County Antrim, UK. Plant Material was gotten at the University of Port Harcourt Abuja Campus, Aluu and was identity by a taxonomist at department of Plant Science and Biotechnology laboratory at the University of Port Harcourt. The leaves were carefully plucked, washed, chopped and sun dried. Furthermore, the samples were oven-dried, macerated to powder and stored until used for the formulation of fish feed at different concentration of the *Bambusa vulgaris* leave meal (BVLM) with other constituents which include wheat bran, soya bean mill, fish mill, vitamin C, lysin, salt etc. The African Cat fish were grouped into seven (7) groups, each group in triplicate. 15 fingerlings in each group (pond). The groups were designated as Control, D1; D2; D3; D4; Fo and Lo. The test groups containing *Bambusa vulgaris* leave mill were the Ds while Fo and Lo are the conventional foreign and local fish feed found in the market. The water quality assessment and measuring of the fish weight, Standard length and Total length was done according to the procedures below:

Water Quality Test

The study was conducted at the African Regional Aquaculture Centre Aluu, Rivers State, Nigeria. Water samples for the analyses were collected from research fish ponds designated as Control, Diet 1; Diet 2; Diet 3; Diet 4; Foreign Feed (Fo) and Local feed (Lo) groups and analyzed immediately. Fish Pond water samples were analyzed for pH, nitrite, NH_3, and Dissolved Oxygen (DO). A Electrochemical Sensors (Polarographic or Galvanic) metre was used to determine Dissolved Oxygen. Water-quality parameters were also tested using the water-test kits. API five-in-one aquarium test strips (API Inc., Chalfont, PA, USA) and Tetra Easy Strips six-in-one aquarium test strips (Tetra Co., Blacksburg, VA, USA) were used to measure nitrite. The DO meter (Hach 146900 DO test kit, Model OX-2P, Hach Co.) and Salifert Profi ki (Salifert, Duiven, Holland) were used to measure DO concentration. The Seneye slide kit (Seneye Ltd, Norwich, UK), Tetra Easy Strips, API test strips, and a Thermo Scientific Orion STAR A15. pH meter (Thermo Fisher Scientific, Inc., Waltham, MA, USA) were used for testing PH. Tetra Easy Strips. Seachem Ammonia Alert (Seachem Laboratory, Madison, GA, USA) and Seneye slide kit were used to measure unionized NH_3. All the water-testing kits were used according to the manufacturers' instructions.

Standard Length

The standard length (SL) of a fish, including most catfish, is a specific scientific measurement. It is the distance from the tip of the snout to the posterior end of the last vertebra, which is typically found at the base of the tail fin (caudal fin). The fish was laid flat on its side on a measuring board next to a measuring ruler. We ensured the fish is as straight as possible. The tip of the snout was placed (the most anterior part of the head, with the mouth closed) against the zero point of the ruler or measuring board. Standard length is measured to the hypural plate (the last bony part of the vertebral column in the caudal peduncle). To find this point, gently bend the tail fin (caudal fin) forward. A crease will form where the fleshy body of the fish ends and the fin rays begin. This crease is known as the hypural crease and indicates the location of the posterior end of the last vertebra. Measure the straight-line distance from the tip of the snout to the hypural crease. This is the standard length.

Total Length

Total Length (TL) is the most common measurement used for recreational fishing regulations and general purposes. Total Length is define d as the maximum length of the fish, measured from the tip of the snout to the furthest tip of the tail fin. The fish was placed on a flat surface, such as a measuring board or a flat ruler/tape measure. Laid the fish on its side, making sure its body is straight (not curved). The fish's mouth was closed and positioned the tip of the snout (the most anterior, or forward, part of the head) against the zero point or "nose block" of the measuring tool. This is the critical step for Total Length: Absolute furthest point of the caudal (tail) fin was included in the measurement. For many fish, including catfish, you need to gently compress or pinch the tail lobes together to get the maximum possible length. The ruler was kept straight, measurement was taken at the very end of the compressed tail fin. The

straight-line distance from the tip of the closed mouth to the furthest, compressed tip of the tail is the Total Length.

RESULTS AND DISCUSSION

Table 1. Determination of Nitrite in the cultured *Clarias gariepinus* pond for twelve (12) weeks

Treatment	Day 0	Day 14	Day 28	Day 42	Day 56	Day 70	Day 84
CTL	0.01±0ab	0±0a	0±0a	0.01±0.01ab	0.1±0.17abcd	0.02±0.01ab	0.01±0ab
D1	0.01±0ab	0±0a	0±0a	0±0a	0.2±0.1d	0.01±0ab	0.01±0ab
D2	0.01±0ab	0±0a	0±0a	0.07±0.12abc	0.14±0.15bcd	0.02±0.01ab	0.01±0ab
D3	0.01±0.01ab	0±0a	0±0a	0.1±0.1abcd	0.14±0.11bcd	0.01±0ab	0.01±0ab
D4	0.01±0ab	0±0a	0±0a	0.11±0.17abcd	0.11±0.16abcd	0.01±0ab	0.01±0ab
FO	0.01±0ab	0±0a	0.03±0.06a	0.17±0.15cd	0.22±0.14d	0.02±0ab	0.01±0ab
LO	0.06±0abc	0±0a	0.03±0.06a	0±0.01a	0±0a	0.01±0ab	0.01±0ab

Mean ±Std. (rows) with different alphabet is significantly ($p<0.05$) different *indicates significant at 5% level of significance

The two-way ANOVA result shows that treatment nitrite are significantly different ($p<0.05$) across days as well as days were significantly different ($p<0.05$). The multiple comparisons using Duncan test shows that treatments are significantly different (indicated by alphabets). This implies that the nitrite for treatments is different for each day period; also the periods were not the same across treatments.

The toxic nitrite concentration for catfish should be <0.6 mg/L (NO_2^- - N) to avoid acute mortality. From the result on day zero (0), the level of nitrite across the test groups 0.01 mg/L except for the local conventional fish feed that got to 0.06 mg/L. No trace of concentration of nitrite on day 14. On day 28, group 6 and group 7 been the foreign fish feed and the local conventional fish feed respectively have nitrite concentration of 0.03 mg/L each. The highest concentration of nitrite was seen on day 56 with the concentration of 0.22 mg/L on group 6 (foreign conventional fish feed). The result shows that the fishes were in a good condition without toxicity. The normal level of nitrite required for the fishes to grow and without toxicity should not be greater than 6.0 mg/L and our results across the groups in the duration of the study proofs the normal requirement of nitrite.

Table 2: Determination of Ammonia in the cultured *Clarias gariepinus* pond for twelve (12) weeks.

Treatment (mg/l)	Day 0	Day 14	Day 28	Day 42	Day 56	Day 70	Day 84
CTL	0.047±0.12cdefg	0.043±0.12defg	0.04±0cdef	0.04±0.12cdefg	0.04±0.17ghi	0.04±0.29efgh	0.04±0j
D1	0.048±0.14cdefg	0.043±0.12defg	0.047±0.12cdefg	0.03±0.12bcde	0.03±0.12bcde	0.02±0abc	0.04±0cdef
D2	0.047±0.12fghi	0.03±0.17hi	0.028±0abc	0.33±0.12bcde	0.05±0.36defg	0.02±0abc	0.04±0.12cdefg
D3	0.04±0.2efgh	0.047±0.12cdefg	0.022±0abc	0.04±0.12cdefg	0.03±0.23bcde	0.027±0.12abcd	0.05±0.12defg
D4	0.047±0.12cdefg	0.04±0.2cdef	0.021±0abc	0.02±0abc	0.03±0.12bcde	0.04±0.12cdefg	0.05±0.12defg
FO	0.047±0.12cdefg	0.043±0.12defg	0.04±0cdef	0.04±0i	0.04±0.06i	0.05±0j	0.05±0j
LO	0.04±0.06ab	0.024±0.01a	0.04±0cdef	0.043±0.15ghi	0.03±0.46j	0.05±0j	0.05±0j

NB: Mean ±Std. (rows) with different alphabet is significantly ($p<0.05$) different

The two-way ANOVA result shows that treatment ammonia are significantly different ($p<0.05$) across days as well as days were significantly different ($p<0.05$). The multiple comparisons using Duncan test shows that treatments are significantly different (indicated by alphabets). This implies that the ammonia for treatments is different for each day period; also the periods were not the same across treatments.

The safe level of ammonia for a fish pond is as close to zero as possible, and definitely must not exceed 0.05 mg/L (or ppm) of un-ionized ammonia (NH_3). The results above showed that the level of ammonia from day zero (o) to the 42nd day across all test groups and the local and foreign conventional fish feed showed the required amount of ammonia level that the fishes can acquire without any sign of toxicity. The lowest amount of ammonia during this period was seen in diet 4 (D4) with the concentration of 0.02±0.01 mg/l on day 14. High amount of ammonia were seen on day 70 and day 84 with the foreign (Fo) and local (Lo) conventional fish feed group with conc. of 0.05±0 mg/l and also with D3 and D4 with 0.05±0 mg/l respectively. This may be due to the high level of growth attained by the fishes in this groups to excrete high amount of ammonia (still termed non-toxic). Ammonia (NH_3) is a major waste product in living organisms, specifically resulting from the breakdown of proteins and nucleic acids. The results proofs that there were no ammonia toxicity among the fishes in all groups during the culture period.

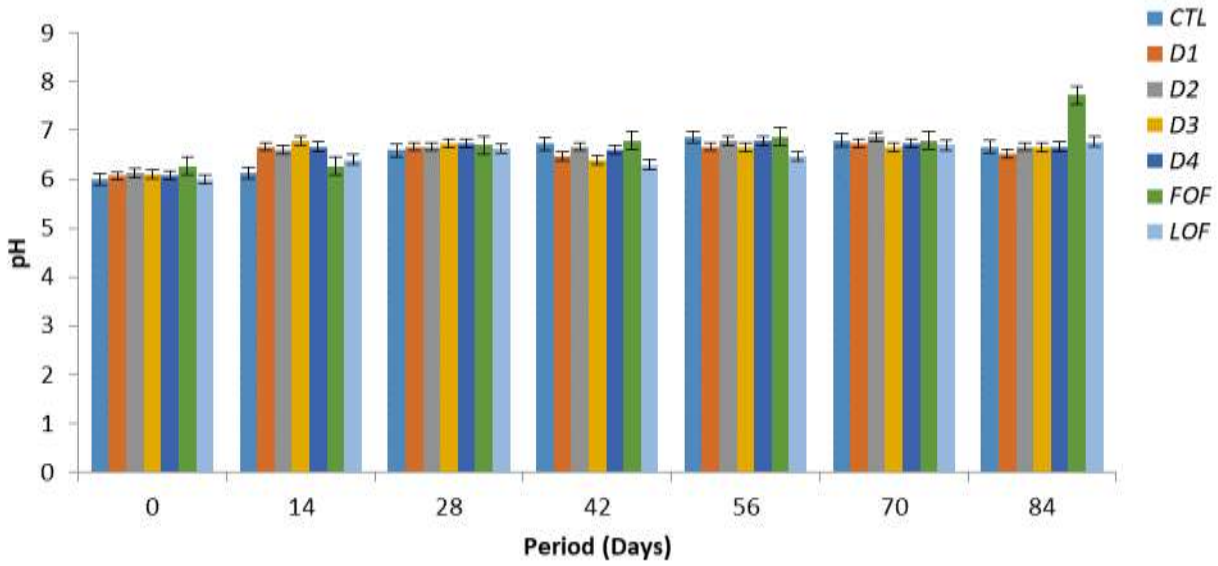

Fig. 1: Determination of pH of the cultured *Clarias gariepinus* for twelve (12) weeks.

The two-way ANOVA result shows that treatment pH are significantly different ($p<0.05$) across days as well as days were significantly different ($p<0.05$). The multiple comparisons using Duncan test shows that treatments are significantly different (indicated by alphabets). This implies that the pH for treatments is different for each day period; also the periods were not the same across treatments.

The pH of a catfish research pond is primarily determined by the carbon dioxide-carbonate-bicarbonate system in the water, which is highly influenced by biological activity and the pond's buffering capacity, the most important factors influencing the pH of the pond water are Photosynthesis and Respiration. Maintaining a stable pH is critical, as extreme or rapid fluctuations can severely stress the fish and increase their susceptibility to disease. pH 6.5 to 8.5 is the Optimal pH for growth, health, and reproduction in fishes. Our result showed that the pH for the duration of the study is from 6.5 to 7.5

across all test groups including the conventional local and foreign fish feed groups. The highest pH was seen in the Foreign Feed group (Fo) with pH level of 7.5 which termed as normal.

Table 3: Determination of Dissolved Oxygen of the cultured *Clarias gariepinus* pond for twelve (12) weeks.

Treatment (mg/l)	Day 0	Day 14	Day 28	Day 42	Day 56	Day 70	Day 84
CTL	1.67±0.58abc	1.67±0.58abc	3±0def	5±0h	3±0def	2.33±0.58bcde	3±0def
D1	2±1abcd	2.67±1.16cde	3±1def	3±0def	2.67±0.58cde	2.67±0.58cde	2.33±0.58bcde
D2	1.33±0.58ab	1.33±0.58ab	2.33±0.58bcde	3.33±0.58efg	2.67±1.16cde	2.67±0.58cde	2±0abcd
D3	2.33±0.58bcde	2.33±0.58bcde	2±0abcd	4±0fgh	3±1def	3±1def	3±0def
D4	2±1abcd	2±0abcd	2.67±0.58cde	5±0h	2.67±0.58cde	2.33±0.58bcde	2.67±0.58cde
FO	2±1abcd	2±0abcd	3±0def	5±0h	3±0def	1.67±1.16abc	3.33±0.58efg
LO	2±1abcd	2±0abcd	4.33±0.58gh	4.33±0.58gh	3±0def	1±0a	3±0def

NB: Mean ±Std. (rows) with different alphabet is significantly ($p<0.05$) different

The two-way ANOVA result shows that treatment Dissolved Oxygen (DO) are significantly different ($p<0.05$) across days as well as days were significantly different ($p<0.05$). The multiple comparisons using Duncan test shows that treatments are significantly different (indicated by alphabets). This implies that the DO for treatments is different for each day period; also the periods were not the same across treatments.

The most important factors determining the Dissolved Oxygen (DO) in a catfish research pond are the balance between oxygen production (mainly photosynthesis) and oxygen consumption (mainly respiration and decomposition), all of which are heavily influenced by temperature and feeding rate.
DO levels in a pond fluctuate dramatically over a 84-days period of the research which is driven by biological activity: Respiration (by fish, plankton, bacteria); Photosynthesis (by phytoplankton/algae); and Decomposition (of waste, uneaten feed, dead algae). The lowest DO concentration occurs just before dawn, as the pond community has been consuming oxygen all night without any photosynthetic replenishment. This is the most critical time for catfish survival.
Warm-water Fish (e.g., Catfish, Tilapia, Carp): These species are generally more tolerant but still thrive when DO is above 5.0 mg/L. For catfish, studies show that while they can survive short periods at 3.0 mg/L, their growth and feed conversion are significantly better when the minimum daily DO is 3.5 mg/L or higher. Result showed that the level of Dissolved Oxygen across the test groups and the local and foreign fish fee group is normal with non above 5.0 mg/L. A high amount of dissolved oxygen were seen on day 42 across all groups with the highest with 5.0 mg/L when compared with the Control across days of treatment (Day 0-84).

Table 4: Determination of Standard Length of the cultured *Clarias gariepinus* for twelve (12) weeks

Treatment	Day 0	Day 14	Day 28	Day 42	Day 56	Day 70	Day 84
CTL	18.23±0.04b	45.66±0.04g	61.84±0.03m	70±0v	73.2±0z	82.25±0.35AH	86.63±0.04AJ
D1	17.91±0.01a	44.85±0.02f	65.43±0.04p	71±0x	73.3±0z	81.33±0.04AF	84.32±0.03AI
D2	18.83±0.04c	47.15±0.21h	65.91±0.01q	68.3±0t	71.5±0y	77.92±0.03AC	80.82±0.02AE
D3	18.2±0.28b	47.25±0.35h	59.1±0l	62.8±0o	65.2±0p	70.73±0.04wx	74.72±0.03AA
D4	20.35±0.49e	50.1±0.14j	62.4±0n	66.9±0s	70.13±0.04v	77.23±0.04AB	70.62±0.02wx
FO	20.44±0.05e	51.25±0.35k	78.7±0AD	87.8±0AK	102.23±0.04AL	111.75±0.21AO	105.23±0.04Am
LO	19.62±0.02d	49.3±0.42i	66.6±0r	69.3±0u	81.92±0.02AG	77.13±0.04AB	82.42±0.02AH

NB: Mean ±Std. (rows) with different alphabet is significantly ($p<0.05$) different

The two-way ANOVA result shows that treatment standard length are significantly different ($p<0.05$) across days as well as days were significantly different ($p<0.05$). The multiple comparisons using Duncan test shows that treatments are significantly different (indicated by alphabets). This implies that the standard length for treatments is different for each day period; also the periods were not the same across treatments.

Determination of Standard Length of the cultured *Clarias gariepinus* is important in knowing the growth performance of the fish. Measuring the standard length (SL) of catfish in a research pond is critical because it provides the most consistent and reliable metric for assessing growth, calculating biomass, and comparing populations. The standard length of the fishes are seen to increase drastically across the test groups and the local and foreign conventional fish feed. In the control group, the increase were seen from 18.23±0. cm at day zero (0) to 86.63±0.04 cm on day 84. The highest increase were seen on day 70 with an increase of 111.75±0.21 cm on the Foreign fish feed group (FoF). The standard length for Diet 4 (D4) can be compared with the local and foreign fish feed groups. The results on the growth performance on the standard length proof that the nutrient in the test groups (BVLM) and the local and foreign conventional fish feed were able to maintain and sustain the growth level from the beginning of the research work to day 84.

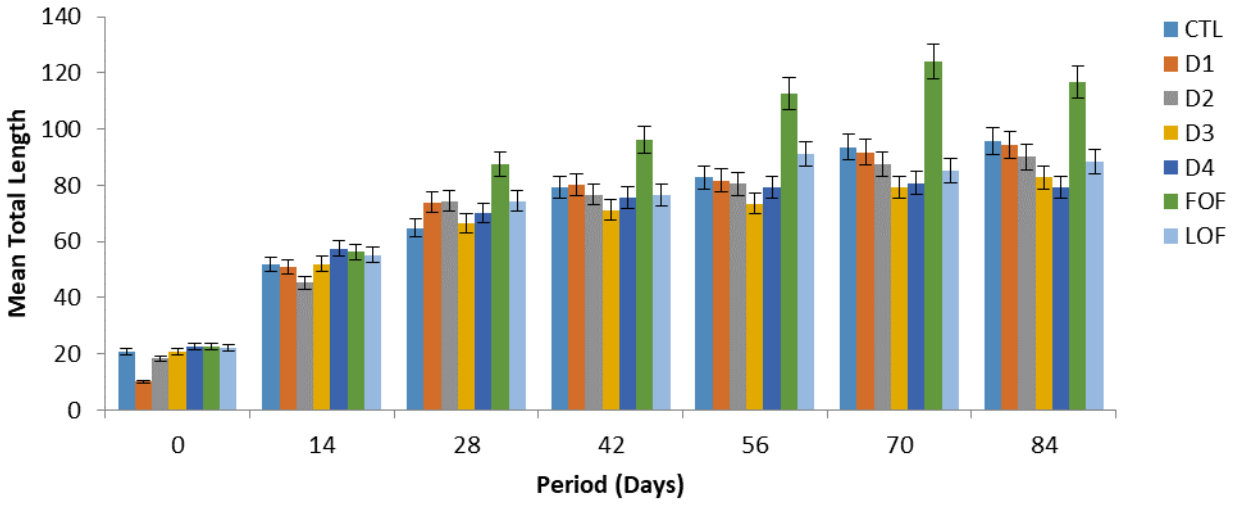

Fig. 2: Determination of Total Length of the cultured *Clarias gariepinus* for twelve (12) weeks.

The Total Length (TL) of a fish is determined by measuring the straight-line distance from the tip of the snout to the extreme tip of the tail fin (caudal fin). The result showed that the total length of the fishes increases drastically across each group for the period of 84 days. The *Bambusa vulgaris* leave meal (BVLM) test groups were seen with incensed growth when compared with the local and foreign fish feed groups. The FoF group were seen with over 100 cm growth rate from day 56 with the highest seen on day 70 with 120 cm, this was also in line with the result obtained from the Standard length on same day as the highest SL. The BVLM test groups can be compared with the LOF groups as the growth progresses from day zero (0) to day 84. This signify high nutritional component on the formulated feed, and thus could be used as a replacement for the high cost local conventional fish feed found in the market.

Table 5: Determination of Weight of the cultured *Clarias gariepinus* for twelve (12) weeks

Treatment (g)	Day 0	Day 14	Day 28	Day 42	Day 56	Day 70	Day 84
CTL	23.92±0.02d	59.94±0.01k	87.25±0.35l	170.2±0.28AF	136.62±0.03w	197.15±0.21AI	263.15±0.21AO
D1	19.22±0.03b	48.26±0.04i	111.33±0.04q	165.15±0.21AC	123.62±0.02t	185.15±0.21AH	254.25±0.35AN
D2	17.21±0.01a	43.15±0.21f	123.34±0.05t	139.15±0.21x	143.2±0.28z	176.25±0.35AG	204.25±0.35AJ
D3	17.62±0.03a	44.25±0.35g	96.61±0.01n	114.35±0.49s	101.62±0.03p	132.63±0.04v	168.15±0.21AE
D4	20.41±0.01c	51.3±0.42j	97.2±0.28o	143.25±0.35z	131.61±0.01u	142.1±0.14y	148.1±0.14AA
FO	44.83±0.04h	112.2±0.28r	220.25±0.35AK	331.2±0.28AP	429.2±0.28AQ	577.54±0.06AS	475.25±0.35AR
LO	36.44±0.05e	91.15±0.21m	150.1±0.14AB	167.45±0.64AD	234.53±0.04AM	176.3±0.42AG	231.4±0.57AL

NB: Mean ±Std. (rows) with different alphabet is significantly (p<0.05) different

The two-way ANOVA result shows that treatment weights (g) are significantly different (p<0.05) across days as well as days were significantly different (p<0.05). The multiple comparisons using Duncan test shows that treatments are significantly different (indicated by alphabets). This implies that the weight for treatments is different for each day period; also the periods were not the same across treatments.

Determining the weight of fish (W) in a research pond is of fundamental importance because it is the most direct measure of growth, nutritional status, and overall health of the fish population. Paired with length (L), weight data is the basis for almost all management, ecological, and physiological studies. Weight data helps researchers understand the biology of the fish such as reproductive cycle and Organosomatic Indices. From Table5, the weight of the fish were seen to increase drastically from day zero (0) to day 84. The weight growth of the control on day 14 with 59.94±0.01g was seen to increase to 263.15±0.21 g on day 84. This growth can be compared with the Local fish feed group (Lo) with higher weight on seen on day 84 with 231.4±0.57 g. The weight gain in D2 group on day 84 with 254.25±0.35 g when compared

with the Lo group with 231.4±0.57 g on day 84 showed that the nutritional value of the formulated fish feed is higher and better than the local conventional fish feed found in the market that was used for the research. The gain in weight of the fishes is in line with the standard length and total length as a proof that the fishes were highly nutritionally stable and in a good condition health wise.

CONCLUSION:

This study investigates the viability of using processed Bambusa vulgaris (bamboo leaf) meal as a sustainable and cost-effective ingredient to partially or completely replace a conventional component (such as maize or soybean meal) in the diet of *Clarias gariepinus* (African catfish) juveniles. The research evaluates two critical factors: the impact of the substituted diets on fish growth and feed efficiency, and the subsequent effects on the culture water quality. The research concludes that processed *Bambusa vulgaris* meal is a viable, sustainable, and cost-effective non-conventional feed ingredient for *Clarias gariepinus*. By identifying an optimal inclusion level (e.g., 10%), the study provides a practical, locally available solution for fish farmers to reduce dependency on expensive, finite resources while maintaining high growth rates and ensuring a healthy aquatic environment. The use of this agro-industrial byproduct contributes positively to the economic viability and environmental sustainability of intensive aquaculture.

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