Evaluation of Growth Performance of Extruded *Irvingia wombolu* (Bitter African Bush Mango) Peel Based Aqua-Feed on African Catfish (*Clarias Gariepinus*) in Nigeria

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Abstract*: As fish feed plays a major role in aquaculture profitability, reduction of cost determines successful productivity. This has necessitated the search for non-conventional feedstuffs that are cheap. The objective of this study is to assess the growth performance of extruded *Irvingia wombolu* (bitter African bush mango) peel based feed in catfish. The peel was sundried, ground into a fine mixture, the proximate analysis was carried out in the laboratory. The ground mixture was mixed with other feed ingredients at different inclusion rate of 5%, 10%, 15% and 20%, an extruder was used to produce fish feed pellets. Fingerlings were stocked ten per plastic tanks (40 litres) with a replicate for each treatment and each tank was filled with 30 litres of water (two-third of the volume of the tank) and water changed daily. Dried fish feed pellets were used in feeding fingerlings of catfish with average weight of 3.8g at 5% body weight for 8 weeks. The growth performance was analyzed to determine the weight gain, specific growth rate, food conversion ratio, survival rate of the fish and digestibility of the feed. SPSS ANOVA statistical analysis was used to analyze the results. The proximate composition of *Irvingia wombolu* peel was discovered to have crude protein (3.9%), crude fat (1.13%), crude fibre (12.37%), ash (4.13%) moisture (10.05%). Results obtained from the experiment showed significant difference ($p<0.05$) in the mean weight gain, feed conversion ratio, and specific growth rate compared with control diet (commercial catfish diet). Feed inclusion rate of 5% *Irvingia wombolu* peel exhibited a good growth performance in terms of weight gain (7.09±0.00), specific growth rate (0.93±20.01) and food conversion ratio (2.31±0.01), followed by 20% inclusion rate with weight gain of 6.84±20.04. However, feed inclusion rate of 15% exhibited highest mortality rate and the lowest growth performance. It can therefore be concluded that inclusion of *Irvingia wombolu* peel into the diet of catfish is non-harmful to the carcass of fish.

***Keywords*: *Irvingia wombolu* peel, *Clarias gariepinus*, proximate composition, extruder, inclusion rate**

I. INTRODUCTION

Aquaculture is one of the fastest growing food production activities in the world. It plays a significant role in many countries by providing a higher income, better nutrition, and better employment opportunities (Kannadhason et al. 2011). The continuous rise in the demand for fish has made aquaculture industry the fastest growing food producing sector in the world. Hence, it continuous growth is largely dependent on the ability of fish feed industry to provide quality feed that are nutritionally balanced for best growth performance of cultured fish. Fish feed plays a major role in aquaculture viability and profitability, because it accounts for at least 40-60% of the total production cost (Shang 1992; Craig and Helfrich 2002; Jamiu and Ayinla 2003). The major nutrients in fish feeds are protein and energy.

Over the past decade, aquaculture has grown in leaps and bounds in response to an increasing demand for fish as a cheap source of protein (Akinrotimi et al. 2007). This is because production from captured fisheries has reached its limit and the catch continues to dwindle by each passing day (Gabriel et al. 2007). According to FAO (2006), fish supplies from capture fisheries will therefore, not be able to meet the growing global demand for aquatic food. The demand and consumption of fish as a cheap source of protein continue to increase in Africa (Akegbesan, 2008). Hence there is the need for a viable alternative fish production system that can sufficiently meet this demand and aquaculture fits exactly into this role. Thus, the aqua-feed technology is moving in tandem with the aquaculture growth with the usage of extrusion procedures for the improvement of digestibility (Kannadhason et al. 2011; Chang and Wang 1999) stated the advantages of extrusion cooking process for aquaculture feed production including improved feed conversion ratio, control of pellet density, greater feed stability in water, better production efficiency and versatility, During extrusion cooking, various reactions take place including thermal treatment, gelatinization, protein denaturation, hydration, texture alteration, partial dehydration, and destruction of microorganisms and other toxic compounds.

The substantial increase in aquaculture production in countries like U.S.A is as a result of aquaculture mechanization which has led to increased productivity, labour efficiency and improved product quality. Unlike Asia, Africa has little aquaculture tradition and has been affected by a number of external problems that have prevented proper management and development despite the investment. A number of countries in sub-Saharan Africa are characterized by low agricultural production, poor management of resources, economic stagnation, persistent political instability, lack of technical knowhow, increasing environmental damage, and severe poverty.

Although aquaculture activities in Nigeria started about 50 years ago (Olagunju et al. 2007), yet Nigeria has not been able to meet domestic production demand for the populace. According to (Ekunwe et al. 2009) statistics indicate that Nigeria is the largest African aquaculture producer, with production output of over 15,489 tonnes per annum, this is closely followed by Egypt with output of about 5,645 tonnes. Only five other countries: Zambia, Madagascar, Togo, Kenya and Sudan produce more than 1,000tonnes each. This result shows that Africa in general is far behind in aquaculture production.

In Nigeria, aquaculture development has been driven by social and economic objectives, such as nutrition improvement in rural areas, generation of supplementary income, diversification of income activities, and the creation of employment. This is especially true in rural communities, where opportunities for economic activities are limited. Only in recent years has aquaculture been viewed as an activity likely to meet national shortfalls in fish supplies, thereby reducing fish imports. Nigeria has the natural resources (such as lands, rivers, streams, reservoirs and lakes; and human resource) and potentials to compete with the world leading aquaculture countries. In spite of these great potentials of natural resources and man-power availability to fish farming in Nigeria, the country is still currently unable to bridge the gap in the short fall between total domestic fish production and the total domestic demand. Meanwhile, millions of Nigerian youth are ready and equally available to work any time of the day. Kareen et al. (2008) reported that the growth in general agricultural sector in Nigeria has fallen short of expectations. Value added per capita in agriculture has risen by less than 1% per year for the past 20 years and food productions gains have not kept pace with population growth, resulting in rising food imports and declining levels of national food self-sufficiency.

Nigeria has a population of over one hundred and forty million people and has her national fish demand at over 2.66 million metric tonnes. The current annual aquaculture production hovers around 0.62 million metric tonnes (FDF 2008). These combined with ever-decreasing catch (due to over exploitation) from the capture fisheries has not been able to meet the ever-increasing protein demand of the country. Whereas small scale fish farming supplies the greatest percentage of the Nigerian's annual fish production output (FDF 2008). However, the production level has been hampered due to high cost of feeding fish coupled with the expensiveness of protein as feed ingredient.

As aquaculture production becomes more and more intensive in Nigeria, fish feed will be a significant factor in increasing the productivity and profitability of aquaculture (Akinrotimi et al. 2007). Jamiu and Ayinla (2003) opined that feed management determines the viability of aquaculture as it accounts for at least 60 percent of the cost of fish production. The need to intensify the culture of the fish as to meet the ever increasing demand for fish has made it essential to develop suitable diets cither in supplementary forms for pond or as complete feed (Omitoyin 2006).

Since the price of feed ingredient is ever increasing, alternative feed sources like use of *Irvingia wombolu* peel needs to be researched so as to sustain fish production in aquaculture without compromising fish growth and health. In the *Irvingiaceae* family of plants, *Irvingia gabonensis* and *Irvingia wombolu* kernels are well known. *I. gabonensis* (also known as dika fruit or sweet bush mango) is known for its edible fruits while I. wombolu is bitter and not eaten but their kernels are used in local food preparations (Leakey et. al., 2005; Ainge et. al., 2001; Okolo, 2000). *Irvingia spp* has been widely used in aquaculture. Kiyasu et. al., (1952) reported that *I. gabonensis* kernel fat has been found to increase the amount of good cholesterol in blood and liver lipids**.**

Fish has high nutritive value above other animal sources of protein and can help solve the global malnutrition problem (Delgado et al. 2003). The expansion and intensification of aquaculture production has been recommended towards ensuring increase in fish food production in order to meet up with the global demand since capture fisheries have continued to be on the decline over decades (Delgado et al. 2003).

In view of the increasing prices of ingredients for aquafeeds, the search for cheap and nutritionally balanced ingredients for fish feed has become an urgent need for the aquaculture sector. Particularly, the evaluation of the nutritional value and potential of locally available nutrient sources is an important aspect for the substitution of conventional fish feed ingredients. Some of which has to do with available data (Ige & Adewale, 2022b) to get valuable insight and also adopting the use of artificial intelligence (Ige & Adewale, 2022a) for future prediction based on changes in biotic and abiotic factor.

Our research objectives were to determine the proximate composition of *Irvingia wombolu* peel and to determine the growth and digestibility of *Clarias gariepinus* using *Irvingia wombolu* peel based aqua-feed at different inclusion rate.

II. RESEARCH METHODOLOGY

Preparation of Samples

The *Irvingia wombolu* peel procured from the south-eastern part of Nigeria and it was passed through a pre-drying process, in which it was exposed to the sun and spread in a soft layer over a plastic canvas for three months. It was then dehydrated to avoid the appearance of fungus. After dehydration, the material was processed to obtain the peel. The samples were ground to fine powder through a 0.5 mm screen using a disc mill (Fedek 2000 Nigeria) to prevent adverse effect on the hydration characteristics on the textures of fibre concentrates.

Chemical Analysis

I. wombolu peel was taken to the laboratory for analysis of crude protein, fat content, moisture content, ash content, crude fibre and nitrogen free extract (NFE) before the experiment. It was added to feed ingredients at varying levels which was used to feed the fish for 8 weeks to check for the growth performance of the fish. Proximate analysis was carried out according to the methods of AOAC (2005).

Diet Preparation

Four nutritionally isocaloric ingredient feed blends were formulated to an isonitrogenous net target of 38% wet basis (wb), using four levels of *Irvingia wombolu* peel inclusion of 5, 10, 15 and 20%. Additional ingredients used in each of the blends included soybean meal, groundnut cake, corn flour, cassava flour, wheat bran, vitamin mix, lysine, salt and mineral mix. The ingredient component of the blend is provided in Table 3.1. Raw ingredients used were procured from the market. The formulate feed was extruded in a single screw extruder with a compression ratio of 5:1, screw speed 405 rpm, screw length of 768 mm and a screw diameter of 32 mm (L/D = 24:1). The extruder temperature was 90ºC, feeding rate 1.44 kg/mm. The mash was allowed to project well inside the cylinder so as to extrude mash when the extrusion point was attained.

Table 3.1: Ingredient Components in the Prepared Feed Diets

Feed ingredient	Mass of ingredients (g/100g)			
	Diet 1	Diet 2	Diet 3	Diet 4
Groundnut cake	16	18	20	22
Soya meal	23.7	21.7	17.9	17.9
Fish meal	22	22	22	22
Wheat bran	20	15	10	5
Corn flour	5	5	5	5
Cassava flour	5	5	5	5
I. wombolu peel	5	10	15	20
DCP	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Lysine	0.1	0.1	0.1	0.1
Methionine	0.1	0.1	0.1	0.1
Vitamin C	0.1	0.1	0.1	0.1
Fish oil	1.5	1.5	1.5	1.5
Vitamin Premix	0.5	0.5	0.5	0.5
Total	100	100	100	100

Experimental Procedure

The best 4 feeds of high protein content and *Irvingia wombolu* peel inclusion ratio of 5%, 10%, 15% and 20% were used to test for growth rate of one hundred fingerlings of *Clarias gariepinus* with an average weight of 3.8 g, the experimental fish were sorted evenly, stocked at 10 fish basin. The fish were acclimatized for 48 hours before feeding commenced. The research was conducted in 10 basins with 5 treatments and a replicate which were fitted with the necessary accessories for the survival of the fish. The feeding process of fish occurred twice per day (morning and evening) at 5% of their body weight daily. The water was changed daily by siphoning.

Growth and Feed Utilization Parameters

Mean Weight gain/day (g/day)

This was determined by dividing the differences in weight between the initial and final weight by the number of days. It is expressed thus:

Mean weight gain (g/day) = $(W2 - W1)/n$
Where W_2 = final weight
W_1 = initial weight
n = no. of days

III. RESULTS AND DISCUSSION

Proximate Composition of Irvingia wombolu Peel

The table 1 shows the proximate composition of *I. wombolu* peel, crude protein (3.69%), crude fat (1.13%), crude fibre (12.37%), ash (4.13%), moisture content (10.05%), NFE (68.65%). Wheat bran is recorded to have 10.32% crude protein, 2.12% crude fat, 3.90% ash, 63.78% NFE and 7.53% crude fibre (FAO 2010) which is low when compared to *Irvingia wombolu* peel. Omojowo et al. (2010) also reported that mango peel meal, moisture content (4.69%), crude protein (6.28%), crude fat (7.25%), crude fibre (5.36%), ash (3.45%) and NFE (72.97%).

Table 1: Proximate Composition of *Irvingia wombolu* Peel

SAMPLE	CRUDE PROTEIN (%)	CRUDE FAT (%)	CRUDE FIBRE (%)	ASH (%)	MOISTURE (%)	NFE (%)
I. wombolu peel	3.69	1.13	12.37	4.13	10.05	68.65

Growth Performance

Mean Weight gain

The growth response of *Clarias gariepinus* fed with various inclusion level of *Irvingia wombolu* peel has been shown in Table 2. The weight gain varies from 7.09±0.01 to 5.78±0.03 and there was significant difference ($p<0.05$) in the weight gain. The highest weight gain was recorded in TD1 and TD5 with a value of 7.09 g and 7.97 g respectively; whereas the lowest in TD3 with value of 5.78 g. Oluwatosin and Solomon (2017) reported that soaked ripe plantain peel can replace maize as high as 100% inclusion level in the diet of *C. gariepinus* without compromising growth performance.

Feed Conversion Ratio

There was significant difference ($p<0.05$) between the feed conversion ratio of the treatments. The higher feed conversion ratio was recorded in TD2 (2.57±0.02) and TD3 (2.53□0.01). TD4 and TD1 had the best food conversion ability with a lowest FCR but not better than TD5 (control group). Carter et al. (2004) observed a better feed conversion ratio in control diet in the replacement of maize with cassava in the diet of Atlantic Salmon (*Salmon salar*).

Specific Growth Rate

There was no significant difference ($p>0.05$) between the inclusion level of *Irvingia wombolu* peel and the specific growth rate of experimental fish (Table 2). Numerically the highest SGR value of 0.93±0.01 was recorded in TD1; while the lowest was in TD3 with 0.81±0.01. It has been documented that 50% replacement of maize with cassava root meal in broiler diet showed no depression in growth or unfavourable feed conversion ratio (Essers *et al*, 1995).

Survival Rate

There was no significant difference (p>0.05) between the inclusion level of *Irvingia wombolu* peel and the survival rate of experimental fish. The highest level of mortality was recorded in TD3 with 90% survival rate while other treatments showed 100%. TD1, TD2 and TD4 gave highest survival rate of 100%. Mortality occurred in the third week and no mortality was recorded in the rest of the weeks of the experiment.

Table 2: Growth Performance Indices

Growth Parameters	DIET 1 (5%) (TD1)	DIET 2 (10%) (TD2)	DIET 3 (15%) (TD3)	DIET 4 (20%) (TD4)	DIET 5 (0%) (TD5)
Initial weight	3.85±0.03	3.90±0.00	3.86±0.02	3.88±0.01	3.84±0.04
Final weight	11.82±0.02	9.85±0.01	9.63±0.01	10.71±0.03	10.93±0.04
Mean weight gain	7.97±0.01	5.95±0.01	5.78±0.03	6.84±0.04	7.09±0.00
Specific growth rate	0.99±0.01	0.82±0.00	0.81±0.01	0.90±0.01	0.93±0.01
Feed conversion ratio	2.31±0.01	2.57±0.02	2.53±0.01	2.31±0.01	2.01±0.02
Survival Rate	100.00±0.00	100.00±0.00	90.00±0.00	100.00±0.00	90.00±0.00

IV. DISCUSSION

Growth Performance

The weight gain observed in the treatments indicates that all formulated diets are nutritionally adequate. The highest value of weight gain was oberserved in TD1 (11.82%) which has a 5% inclusion level of I. wombolu followed by TD5, TD4 and TD2. The weight gain of the fish of TD3 gave the lowest growth performance and these may be attributed to poor acceptability of the diet by the fish. The specific growth rate recorded was similar to the 0.87% obtained by Aderolu (2010) for *Clarias gariepinus* fed cocoyam. Also, the result obtained in this study is in agreement with the result obtained by Omoregie et al. (1991) when they included cassava peelings and mango seeds in the diet of *Oreochromis niloticus*. Olurin *et al*., (2006) also reported a replacement level of 50% cassava meal for maize without a depression growth in *C. gariepinus***.**

Water Quality

The mean water quality parameter used in this study were within the temperature range of 25-28ºC which is within the temperature range for optimum growth of catfish and tilapia as reported by Idodo (2003). Boyd and Lictchkoppler (1989) recommended a temperature range of 25–32°C for best growth of warm water fish and Aderolu and Sogbesan (2010) recorded a temperature range of 27.5–29.5°C for *Clarias gariepinus* fed with graded level of cocoyam. The mean pH value recorded was in accordance with that obtained by Omitoyin (2006) for intensive fish culture.

Apparent Digestibility Coefficient of Feed Containing Different Inclusion Levels of Irvingia wombolu Peel for Clarias gariepinus

The result of the digestibility was presented in Table 3. The crude fibre content of *Irvingia wombolu* peel has the highest digestibility value when compared with others (ash, crude protein, fat). The highest crude fibre digestibility was observed in TD4 (20% inclusion rate) and TDI (5% inclusion rate) followed by TD5 (0% inclusion rate) and TD2 (10% inclusion rate) with a percentage of 62.81%, 60.82%, 59.81 and 59.50% respectively. TD3 (15% inclusion rate) has the lowest crude fibre digestibility when compared with other inclusion levels with percentage of 58.13%. This indicates that *Irvingia wombolu* peel might be a good source of fibre in diet of African catfish. The highest crude protein digestibility was observed in TD4 (20% inclusion rate) which also has the highest fat digestibility. TD1 (5% inclusion rate) has the highest ash digestibility with value of 29.37 and it also has the lowest NFE value of 8.24% which indicates that it was more utilized than other inclusion level Sklan et. al. (2004) reported that high content of diet fibre decreases the access of digestible enzymes to nutrients.

Table 3. Apparent Digestibility Coefficient of Feed Containing Different Inclusion Levels of Irvingia wombolu Peel for Clarias gariepinus

Treatments	TD1 (5%)	TD2 (10%)	TD3 (15%)	TD4 (20%)	TD5 (0%)
Crude protein (%)	38.95	42.31	39.96	44.20	41.18
Ash (%)	29.37	15.44	14.84	25.30	16.32
Crude fibre (%)	60.82	59.50	58.13	62.81	59.81
Fat (%)	3.49	6.58	4.85	8.75	7.29
NFE (%)	8.24	13.73	10.10	17.36	14.30

V. CONCLUSION AND RECOMMENDATION

The substitution of extruded feed which includes *I. wombolu* peel used in the diet of *Clarias gariepinus* was studied in this experiment. The result showed that *I. wombolu* peel improved the growth and survival rate of the fish. The fish fed TD1 containing 5% *I. wombolu* peel inclusion level gave the best growth performance in terms of weight gain, specific growth rate and feed conversion ratio which indicated that it was optimum for growth performance of *Clarias gariepinus*. TD3 with 15% inclusion level gave the lowest performance. With the above result, it can therefore be concluded that the inclusion of *I. wombolu* peel in diet of *Clarias gariepinus* is non-harmful to the fish and it can be added up to a level of 5% inclusion. *Irvingia wombolu* peel can therefore be recommended in the diets of *Clarias gariepinus* and further research should be carried out on usage of *I. wombolu* for diets of *Clarias gariepinus* also, the nutritional benefits of *I. wombolu* should be researched for more usage on fish.

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