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Nutrient Utilization of Nile Tilapia Fed Enzyme Supplemented Cassava Peel Meal Based Diet

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ABSTRACT

An eight-week feeding trial was conducted to determine the effect of incorporating enzyme-supplemented cassava peel meal (ESCPM) as an energy source to replace maize in the diet of Nile tilapia (Oreochromis niloticus). Five diets containing 40% crude protein were formulated in which ESCPM replaced maize at 0% (control), 25%, 50%, 75 and 100%, respectively. 70 fingerlings of Oreochromis niloticus weighing 2.36±0.06g were randomly distributed into 5 treatments of 14 fish each, replicated twice. The fish were fed at 5% body weight daily. Results indicated a significant difference (P<0.05) in mean weight gain (MWG), specific growth rate (SGR) and feed conversion ratio of the fish fed the diets. However, the fish fed with 0% (control) diet recorded the best MWG (18.90), (SGR) 1.72 and FCR (0.83) while the fish feed 100% inclusion level of ESCPM recorded the least values with 10.33, 1.29 and 1.32 in MWG, SGR and FCR, respectively. It was concluded that Oreochromis niloticus could not tolerate up to 100% inclusion level of ESCPM without deleterious effects. Nevertheless, 50% inclusion level showed the best nutrient utilisation and growth response among the ESCPM treatments fed to Oreochromis niloticus. Based on the results obtained, enzyme-supplemented cassava peel meal can be recommended as a substitute for maize in practical fish feed formulations for Nile tilapia (Oreochromis niloticus), as it enhances nutrient utilisation and supports optimal growth performance.

Keywords: *Cassava peel, Nile tilapia, Fingerlings, Enzyme, energy source*

INTRODUCTION

Food production from aquaculture has continued to expand over the last decade, with the percentage contribution from aquaculture to total fish production rising from about 50million tonnes in 2007 to about 67million tonnes in 2012 (FAO 2014). However, the rapid growth comes at the expense of sustainability hence the challenge of combating disease, increasing growth rates, producing more efficient feed, improved larval rearing and finally a food product that meets nutritional and safety standards (Cheikyula et al., 2020). In aquaculture, 50-60% of production costs usually emanate from feed cost (Nates, 2016). According to Sunarno et al. (2017), in intensive tilapia cultivation, approximately 70% of the total production cost is used for feed. Consequently, the need for artificial feed continues to increase along with the rising demand for aquaculture products (Suprayudi et al., 2015; Hermawan et al., 2021). The availability of major raw materials used for manufacturing aqua-feeds, such as fish, soybean, and meat meal, is still dependent on imports, and the price is increasing in the market (Mukti et al., 2019). This dependence needs to be avoided to reduce the price of artificial feed and increase profits in fish farming (Hakim et al., 2019).

Cereals, especially maize, have been the major energy source in fish diets, and it is about 10-40% by weight in most aqua-feeds. The high cost and scarcity of maize in formulated feeds has led to the search for under-utilised energy sources such as cassava by-product, oil cakes, rice milling wastes, etc., which are readily available and affordable. Cassava is one of Nigeria's most common and essential staple crops, recognised as a 21st-century crop primarily for smallholder farmers. Accounting for abount26% of global producers of cassava in the world, producing over63 million tonnes of cassava in 2021. More than 90% of cassava produced in Nigeria is processed as food and consumed locally (LinkedIn.com, 2023). Considering this fact, it is believable that cassava peels are in abundance. It is an observed predominant waste from the processing of garri, cassava flour and starch. Hermanto and Fitriani (2019) stated that the waste from cassava peels was approximately 16% of the weight of the tuber. The nutritional content in 100g of CPM includes 4.08% protein, 4.02% fat, 56.06% carbohydrates, and 27.23% crude fibre (Mirzah and Muis, 2016). Furthermore, it contains anti-nutritional substances, namely cyanide (Stephanie and Purwadaria, 2013). The high crude fibre content and the presence of cyanide inhibit the use of this meal as a raw material for fish feed (Putra et al. 2022). However, various processing methods aimed at eliminating or reducing the constraints associated with cassava peel utilisation in animal feeding have been explored, with documented reports of their successful outcomes.

Tilapia (Oreochromis niloticus) fish farming is becoming popular as demand for fish keeps growing. Tilapia is the second most farmed fish in the world. The world aquaculture production of tilapia fish is 4.2 million tonnes with an estimated value of around $3 to $3.5 billion. Tilapia fish is among the earliest and most profitable fish to farm due to their fast growth, omnivorous feeding habits, resistance to diseases, high stocking densities, wide market acceptability, etc. By changing to an alternative ingredient, the aim is not only economical but also the sanitation of the environment of unutilized agro-waste. The study, therefore, aims to determine the effect of feeding varying inclusion levels of maize with enzyme-supplemented cassava peel meal on the growth of Oreochromis niloticus and to determine the optimum dietary inclusion that will support its growth.

MATERIALS AND METHOD

Experimental site

The experiment was conducted at the Teaching and Research Farm of the Department of Fisheries Technology, Federal Polytechnic Nekede, Owerri, Imo State.

Experimental fish

A total of seventy (70) fingerlings of monosex Nile tilapia (*Oreochromis niloticus*) with average weight of 2.36+0.06g were obtained from Ghana by flight. The fish were acclimatized for 7days in a nursery tank and starved for 24hours to empty their gastro-intestinal tract prior to being placed on experimental diets. The experimental fish were randomly distributed into five (5) groups that represented the dietary treatment at the rate of 7fish with two replicates each.

Source of cassava peel

Fresh cassava peels were obtained from a local cassava mill in Oguta, Imo state. It was sorted to remove all trash, washed and sundried for 10days after which it was ground to fine powder for easy mixing and distribution of other ingredients in the experimental diet. Thereafter, the CPM powder was kept away from wetness until it used in the formulation of the experimental diets.

Experimental diets and feeding

The feeding ingredients were obtained from Fidelity Agro Services (Nigeria) Egbu Road Owerri, Imo state. Five diets were formulated to contain 40% crude protein I which cassava peel meal maize at 0% (control), 25% 50%, 75% and 100% respectively. The ingredients composition is as shown in table 1. The ingredients for each diet were measured out, mixed thoroughly in a bowl to obtain a homogeneous mass and 1000ml hot water to obtain a dough-like paste. The diet was pelleted in a manually operated pelletizer the moist pellets were sundried to crispy condition, packaged in tagged air-tight polythene bags and stored at room temperature. The experimental fish were fed twice daily, morning (8-9am) and evening (4-5pm) at 5% body weight. Sampling of the fish was done every two weeks to obtain the body weight of test fish. This was used to adjust the quantity of feed fed to the fish.

Proximate Analysis of the Cassava Peel

Moisture content
Moisture content was determined by oven dry method (AOAC 2005)

Crude protein
Crude protein was determined by the Kjedahl method described by Pearson (2005). The total nitrogen was determined and multiplied by the factor 6.25

Crude fat
Crude fat was determined using the Soxhlet method (AOAC, 2000)

Ash content
The ash content was determined by incineration method (AOAC, 1990)

Crude fibre
The crude fibre was determined in the Weende method as described by Pearson (1976).

Total carbohydrate
The total carbohydrate was determined by estimation as the nitrogen free extract (NFE)
% NFE = (100-%moisture + %protein + %Crude fat + %crude fibre + %Ash)

Table 1: Gross composition of experimental diets fed to Nile tilapia fingerlings

			Inclusion levels		
Ingredients	**0%**	**25%**	**50%**	**75%**	**100%**
Cassava peel meal	0.00	5.00	10.00	15.00	20.00
Maize	20.00	15.00	10.00	5.00	0.00
Soybeans	46.00	46.00	46.00	46.00	46.00
Blood meal	10.00	10.00	10.00	10.00	10.00
Fishmeal	18.00	18.00	18.00	18.00	18.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Vegetable oil	2.00	2.00	2.00	2.00	2.00
Vitamin premix	1.00	1.00	1.00	1.00	1.00
Methionine	0.50	0.50	0.50	0.50	0.50
Lysine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**

Data collection

The entire fish was randomly sampled and weighed from each treatment once in two weeks and then returned thereafter into their respective hapas; which are netted enclosures or cages installed within ponds or water bodies and used to confine and manage experimental fish groups under controlled conditions. Feeding was adjusted in respect to the sapling results obtained to their new body weights.

Data analysis

The raw data obtained after the mineral analysis on wet weight were subjected to one way analysis of variance (ANOVA) using SPSS (Version 20.0) to determine the significant differences among the means of the species. Duncan multiple range test was used to separate the means at 5% level of significance.

RESULTS AND DISCUSSION

Table 2: Proximate composition of the test ingredients (enzyme supplemented cassava peel meal)

Parameters	Composition (%)
Moisture	7.23
Crude fibre	12.15
Crude protein	11.38
Ash	9.73
Crude fat	6.11
Nitrogen free extract (NFE)	53.40

Table 2 presents the proximate composition of the enzyme-supplemented cassava peel meal (ECPM) used as a test ingredient in the experimental diets. The ingredient is characterized by a high nitrogen-free extract (NFE) content (53.40%), indicating that cassava peel meal is predominantly an energy-rich ingredient due to its high carbohydrate fraction. This energy contribution is important in fish nutrition, as adequate dietary energy supports protein sparing and enhances nutrient utilization efficiency. The crude protein content (11.38%) is relatively low compared to conventional protein sources such as maize or fish meal, confirming that cassava peel meal primarily serves as an energy source rather than a major protein contributor. The crude fibre level (12.15%) is moderately high, which is a known limitation of cassava peels in monogastric and fish feeding; however, enzyme supplementation is expected to improve fibre degradation and nutrient availability. The ash content (9.73%) suggests a reasonable mineral contribution, while the crude fat level (6.11%) provides additional dietary energy, supporting metabolic functions and growth.

Table 3: Proximate composition of experimental diets fed

	Dietary levels				
Ingredients	**0%**	**25%**	**50%**	**75%**	**100%**
Moisture	4.99	4.59	4.61	7.45	6.78
Crude fibre	2.77	14.23	7.84	15.09	15.50
Crude protein	48.24	42.38	43.01	36.59	36.32
Crude fat	13.90	13.87	14.90	11.50	11.39
Ash	7.71	7.65	9.55	8.88	10.12
NFE	22.39	17.28	20.09	20.49	19.89

Table 3 shows the proximate composition of the experimental diets formulated with graded levels (0–100%) of enzyme-supplemented cassava peel meal as a replacement for maize. A clear trend is observed as inclusion levels increase. Moisture content remains relatively low across diets, indicating good feed stability and storage quality. Crude fibre content increases with higher inclusion levels of ECPM, particularly at 75% and 100%, reflecting the higher fibre content of cassava peel meal compared to maize. Despite this increase, enzyme supplementation is expected to enhance fibre breakdown, thereby improving digestibility and nutrient utilization in Nile tilapia.

Crude protein levels decrease progressively as cassava peel meal inclusion increases, from 48.24% in the control diet (0%) to about 36% at 75–100% inclusion. This reduction is attributable to the lower protein content of cassava peel meal relative to maize and other protein sources in the diet. Nevertheless, the protein levels across all diets remain within acceptable ranges for Nile tilapia growth, suggesting that protein requirements were adequately met. Effective nutrient utilization, therefore, depends not only on crude protein concentration but also on improved digestibility facilitated by enzyme supplementation.

Crude fat content shows only slight variation among diets, indicating that energy density was relatively maintained despite increasing cassava peel inclusion. Ash content tends to increase with higher inclusion levels, suggesting an improved mineral contribution from cassava peel meal, which may support metabolic and physiological processes in fish. The NFE values remain fairly stable across diets, confirming that the diets consistently supplied carbohydrates as an energy source, which is essential for efficient nutrient utilization and growth performance.

Overall, the results from the study showed that there was a general increase in the growth response among the experimental fish fed different dietary groups.

Table 4: Anti-nutrient composition of the test ingredients (enzyme supplemented cassava peel meal)

Parameters	**Composition (mg/100g)**
Tannin	8.16
Total phenol	8.02
Phytate	135.88
Oxalate	0.62
Phyting phosporous	38.28
Cyanogenic content (HCN)	6.36

The result of the proximate composition of cassava peel meal (Table 4) showed crude content of 11.38%. This protein value is relatively higher than the crude protein of maize (10%), but lower than 12.30% reported by Ezereonye (2001) from fermented cassava peel meal. This might be as a result of fermentation.

The values of crude fibre and crude fat contents are 12.15% and 6.11% respectively. This dietary fat of 6.11% obtained in cassava peel is within the acceptance range recommended by Teshima and Kanazawa (1986) who reported that dietary lipid content from 4-12% could increase the protein efficiency ratio and weight gain in tilapia.

Nevertheless, the result showed that the growth performance of the experimental fish fed trial diets were significantly different ($p>0.05$) in mean weight gain, specific growth rate, feed conversion ratio and protein efficiency ratio. However, the experimental fish fed 0% (control) diet obtained the best result in mean weight gain, specific growth rate and fed conversion ratio compared to the fish fed other dietary groups (25%, 50%, 75% and 100%). This might be as a result of high protein and fat content of the control diet (48% and 13.90%) and low fibre content (2.77%). This is followed by fish fed 50% ESCPM with values 15.38, 1.55, 2.78 and 0.99 for mean weight gain, specific growth rate, protein efficiency ratio and feed conversion ratio respectively. This result is in agreement with the findings of Soltan *et al.,* (2005) and Saleh (2001) in which they reported that substituting yellow corn with potato by-product meal at 50% level of inclusion in Nile tilapia diet enhanced nutrient utilization without deleterious effect. Aguihe *et al.* (2015) reported that birds on 50% CPM enzyme diet had a significant ($P<0.05$) higher weight gain and feed intake followed by those on 75% CPM diet as compared to control group. Adejoke (2018) reported that replacing maize with up to 50% replacement level of cassava peels fermented with wastewater from the fermented cassava pulp is not deleterious to growth and nutrient utilization of *C. gariepinus*.

Fish fed diet containing 100% ESCPM recorded the least performance in MGW (10.33), FCR (1.32) and SGR (1.29) PER (1.90). This can be traced to low protein content (36.32), higher fiber content (15.50) and possible interference of anti-nutrients at high levels such as phytate and tannin. This resulted in reduced palatability hence, reduced feed intake (13.60) (Oresegun *et al.,* 2001).

Table 5: Growth Performance of Nile tilapia fed enzyme supplemented cassava peel meal

			Dietary			
Ingredients	**0%**	**25%**	**50%**	**75%**	**100%**	**SEM**
Initial weight	2.30[a]	2.41[a]	2.41[a]	2.41[a]	2.41[a]	0.02
Final weight	21.20[a]	17.22[bc]	17.79[b]	15.16[c]	12.74[d]	1.69
Weight gain	18.90[a]	14.81[bc]	15.38[b]	12.38[c]	10.33[d]	1.71
SGR (%/day)	1.72[a]	1.53[bc]	1.55b	1.43c	1.29d	0.09
MFI (g)	15.80[b]	16.25[a]	15.52[bc]	14.71[c]	13.60[d]	0.53
FCR	0.83[a]	1.10b[c]	0.99[b]	1.15[c]	1.32[d]	0.01
PER	3.01[a]	2.28[bc]	2.78[b]	2.17[c]	1.90[d]	0.22
PI	6.32[b]	6.50[a]	6.21[bc]	5.88[c]	5.44[d]	0.22

SGR = Specific Growth rate (%/day) = 100 (log final – log initial)/days
MFI = Mean feed intake (g)
FCR = Feed Conversion ratio = Total feed intake (g)/ Total weight gain (g)
PER = Protein Efficiency Ratio = Weight gain (g) / total protein intake (g)
PI = Protein Intake = Feed intake (g) x crude protein

Table 5 reveals that mean feed intake decreased as the level of ESCPM in Nile tilapia diets increased except for the 25% group. The same trend was observed with mean weight gain except for the 50% dietary group. The values of FCR were 0.83, 1.10, 0.99, 1.55 and 1.32 for 0%, 25%, 50%, 75% and 100% respectively, there was significant difference ($p<0.05$) among the dietary groups. The FCR result agrees with the findings of Carter *et al.,* (2003), who reported a better feed conversion ratio in control diet in the replacement of maize with cassava in the diet of Atlantic salmon (*Salmon salar*). The PER varies from 3.01 to 1.90, and the highest ($p<0.05$) value was obtained by 0% (control) group compared to other diets containing ESCPM. The highest PER (3.01) value recorded in 0% group and the serial decrease in 25%, 50%, 75% and 100% is in concomitant with Wee and Wang (2002) report in which very poor PER was obtained at high levels of plant protein sources.

The general increase in body weight of the experimental fish in all the treatments indicated that the diets were adequate in essential nutrients especially dietary protein (30-35% CP) required by Nile tilapia (*Oreochromis niloticus*).

CONCLUSION

Overall, the results demonstrate that enzyme-supplemented cassava peel meal can be effectively incorporated into Nile tilapia diets as a maize substitute. Although higher inclusion levels increase dietary fibre and slightly reduce crude protein, enzyme supplementation likely enhances nutrient digestibility and utilization. This supports the study's title by showing that ECPM-based diets can provide adequate nutrients for Nile tilapia, thereby promoting efficient nutrient utilization and sustaining growth performance when properly formulated.

The replacement of maize with enzyme supplemented cassava peel meal diets produced the best results in terms of growth response and nutrient utilization at 50% inclusion level. However, other inclusion levels, 25%, 75% and 100% responded well to show that they can as well be used as supplemental in fish feed formulation for Nile tilapia (*O. niloticus*).

The advantages of using cassava peel meal as dietary energy source may rely on the fact that CPM is cheap and readily available compared to maize.

RECOMMENDATIONS

Based on the results obtained, enzyme-supplemented cassava peel meal can be recommended as a substitute for maize in practical fish feed formulations for Nile tilapia (*Oreochromis niloticus*), as it enhances nutrient utilization and supports optimal growth performance.

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