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Original Article

Effects of co-fungal fermented rice bran on growth performance, feed conversion and carcass composition of *Clarias gariepinus* fingerlings

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Abstract

Fish meal was partly replaced with various concentrations of co-fungal treated rice bran and fed to African catfish *Clarias garipienus* for 58 days with an initial mean weight of 6.04 g. Five isonitrogenous diets were formulated namely with 0% (control diet/D_0), 20% (D_{20T}) and 50% (D_{50T}) of co-fungal treated rice bran, and with 20% (D_{20U}) and 50% (D_{50U}) untreated rice bran to substitute for fish meal. *Clarias garipienus* fed with D_0 and D_{20T} had the highest survival rates of 80%, while the group fed with D_{50T} had the lowest survival rate. Maximum weight gain (84.312 g) and specific growth rate (200.76 %/week) were observed in the group fed with D_0, while lower values in the other groups. The carcass composition of the group fed with D_{50T} had a higher protein content than in the group fed with D_0, and the fish fed with co-fungal treated bran had improved nutritive carcass composition.

Keywords: *Clarias garipienus*, rice bran, growth performance, nutrient utilization, isonitrogenous diets

1. Introduction

The African catfish, *Clarias gariepinus* is of great economic importance as a major source of income, and it is an affordable source of protein to an average Nigerian. It reduces the unemployment rate and boosts the Gross Domestic Product (GDP). Unlike tilapia, catfish are sold at the market faster due to their better market value (Emokaro, Ekunwe, & Achille, 2010). The rearing of catfish requires less space, money, and time with a higher feed conversion rate. It provides animal protein to the populace because of its excellent biological index in terms of higher protein assimilation and retention of protein in the body, and lowers the cholesterol content in comparison with other protein sources (Anoop, Sundar, Khan, & Lal, 2009). The demand for it is so high that no matter the quantity supplied to the market, buyers would always be available for either the smoked or the fresh form (Vanguard, 2009; Olayemi & Akinwande, 2013). Its byproduct is the most vital ingredient for the formulation of commercial pelleted feeds. As a way of reducing the cost of aquaculture production, fish farmers are now replacing fishmeal with alternative cheaper and readily available protein sources that are easier to produce and sustainable (Odoh, Abuh, Haruna, Yisa, & Bids, 2019).

Total dependence on fishmeal in aquaculture systems as a vital ingredient to formulate fish feed has increased its use by 20 to 50% over what is generated by the farmed products (Naylor *et al.*, 2000; Ozório, Portz, Borghesi, & Cyrino, 2012). The scarcity of high quality fishmeal and the wide margin between the demand and supply have resulted in the escalation of its price, and this might eventually impede further development of aquaculture (Bob-Manuel & Alfred-Ockiya, 2011; Siddhuraju & Becker, 2001; Tacon & Metian, 2013). Therefore, a series of efforts are being made globally to develop substitutes from cheaper and readily available protein sources to replace the scarce and expensive fishmeal in aquafeeds, and to relieve the pressure on fishery resources. Complete or partial replacement of fishmeal by other cost-effective protein sources is the most pressing matter in aquaculture research due to unabated increase in the price of

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fishmeal. The evaluation of various plant materials in terms of nutritional contents as alternatives to fishmeal in aquatic diets has been well pursued (Mondal, 1999; Tacon & Metian, 2015). The use of cost-effective plant proteins (PP) is limited by their lack of minerals, essential amino acids, multiplex carbohydrates, and the occurrence of anti-nutritional factors (ANFs) (NRC, 1993; Vielma, Koskela, Ruohonen, Jokinen, Kettunen, & Vielma, 2003).

Fermentation is a simple and cheap biological treatment to eliminate the anti-nutritional factors and the indigestible crude fiber contained in the plant protein (Bairagi, Sarkar, Ghosh, Sen, & Ray, 2002). Co-cultural or mixed culture techniques using microbial strains in the nutritive improvement of agricultural wastes have been reported to be efficient biological tools, which is attributed to the establishment of synergy between the two microbial strains (Olaniyi, Bankefa, Ibitoye, & Familoni, 2015). We used this technique to remove ANFs from rice bran and used the fermented end-product as feedstuff to replace fish meal in catfish diet.

Millions of tons of agricultural wastes are generated annually in Nigeria from both large- and small-scale farming activities. Some of these wastes are underutilized or left to undergo natural decomposition out in the open field causing environmental pollution hazards. Those that are utilized do not have their full potential exploited. These wastes might be harnessed in the livestock industry for the preparation of animal feeds and they include rice bran, palm kernel cake, corn cob, wheat bran, cassava peels, and many more. Microbial bioconversion, chiefly fungal bioconversion of wastes, seems to be a practical and promising alternative for improving their nutritional content and metamorphosing them into animal feed (Agosin, Monties, & Odier 2006; Ke, Wu, & Zhang, 2011; Villas-Bôas, Esposito, & Mendonça, 2003). Co-fungal bioconversion of agricultural by-products is an environmentally friendly biotechnological process to enrich these wastes (Huettermann, 2000; Karunanandaa, Varga, Akin, Rigsby, & Royse, 1995; Mukherjee & Nandi, 2004; Zhang, Li, & Fadel, 2002). Unfermented agricultural wastes are unacceptable as feed ingredients, as they are deficient in digestible protein coupled with the fact that essential components of these wastes are freely available for animal gut digestion (Song, Fang, Wang, & Wang, 2009). The growth of microorganisms, such as fungi, on agricultural residues, increases their protein and vitamin contents (Ke *et al*., 2011). The objective of this study was to investigate the effects of partial fishmeal replacement by co-fungal fermented rice bran on growth performance, feed conversion and carcass composition of *Clarias gariepinus* fingerlings.

2. Materials and Methods

2.1 Fungal isolates

Penicillium italicum and *Trichosporonoides oedocephalis* have been earlier established to possess hemicellulolytic activities (Olaniyi & Akinyele, 2014) and these were sourced from the Research Laboratory, Microbiology Department, the Federal University of Technology Akure (FUTA), Ondo State, Nigeria. The fungal cultures were maintained on Malt Extract Agar (MEA) and sub-cultured at an interval of three weeks. They were incubated at 30±2 ºC until the entire plates were covered by active mycelia and stored at 4 ºC in a refrigerator on agar slants. Rice bran was procured from a reputable rice mill in Akure, Ondo State, Nigeria, and it was utilized as a substrate for solid-state fermentation. The substrate was oven-dried at 70 ºC for 2 h with Model DHG Heating Drying Oven, then stored in airtight transparent plastic containers to keep it moisture free. All chemicals were of analytical grade.

2.2 Co-fungal treated rice bran

Fermented rice bran was prepared using solid-state fermentation by suspending 10 grams of the coarsely ground rice bran in 250 ml Erlenmeyer flasks containing 33 ml Mandels and Weber's medium modified from El-Naggar, El-Aassar, Youssef, El-Sersy, and Beltagy, (2006). After sterilization at 121 ºC for 15 min, the suspended substrate in the basal medium was cooled and inoculated with two agar blocks of the test organisms and their respective fungal associations were used as inocula and incubated at 30 ±2 ºC for 20 days in the culture room. This medium (moistening agent) contained the following ingredients (g/L): Peptone 2, yeast extract 2, $NaNO_3$ 2, K_2HPO_4 1, $MgSO_4.7H_2O$ 0.5, KCl 0.5 and $FeSO_4.7H_2O$ traces. After co-fungal treatment, samples were air-dried and kept in shadow for 24 h to reduce the excessive moisture. Afterward, the samples with reduced moisture content were further dried in an oven at 55 ºC for 48 h until a constant weight was reached, and then kept in airtight containers for fish feed formulation. The proximate composition of co-fungal treated rice bran was determined following the standard protocol of AOAC (2012).

2.3 Experimental fish and preparation of experimental diets

Two hundred and fifty fingerlings of *Clarias gariepinus* of the same stock and of average 6.04±0.5g initial weight were used for this study. They were purchased from a reputable fish farm and transported to the experimental site on the 25th of April, 2013.

Control diet (D_0) was prepared using fish meal as the main protein source, while in the experimental diets, fishmeal was partly substituted for by co-fungal fermented (D_{20T} and D_{50T}) or by unhydrolyzed rice bran (D_{20U} and D_{50U}) at graded levels of 20 and 50% inclusions, respectively. Five isonitrogenous (40% crude protein) diets were formulated and are designated as follows to label the dietary treatments:

T1 = commercial fish feed (control ration)/D_0
T2 = 20% fungal treated rice bran inclusion/D_{20T}
T3 = 20% untreated rice bran inclusion/D_{20U}
T4 = 50% fungal treated rice bran inclusion/D_{50T}
T5 = 50% untreated rice bran inclusion/D_{50U}

2.4 Experimental setup

A total of ten (10) glass tanks were used for the study. The aquaria were washed thoroughly and each was filled with 20 liters of dechlorinated water. The aquaria were labeled for easy identification and each of them represented a treatment. Each treatment (diet) was run in triplicate. The experimental fish were weighed and randomly distributed at the rate of 15 fish/glass tank.

The experiment was carried out for 58 days. After stocking, the experimental fish were acclimatized for a week without being fed co-fungal treated diets (Mondal, Kaviraj, & Mukhopadhyay, 2012). The fish were fed with the five experimental diets at 5% of body weight twice daily. The daily ration was split into two and dispensed at 0900 and 1600 h. The fish were weighed (in grams, g) weekly using a top-loading weighing balance (Mettler Toledo, PB3002 London) and the new feeding regime was adjusted accordingly. Each day before feeding, the fecal matter in the tanks was siphoned, while complete draining and cleaning of the tanks was carried out once every three days to ensure a healthy environment for the fish and to maintain good water quality.

The weight of the experimental fish was determined for each of the aquaria immediately after acclimatization using an electronic top-loading Mettler balance (Model PB 3002). The mean weights of fish per tank were recorded. The weighing continued weekly until the experiment was terminated at 58 days of cultivation. Samples of the experimental diets and carcass quality of the fish were analyzed for their proximate compositions according to the standard methods of (AOAC, 2012).

The following indices were determined:

Weight gain = $W_2 - W_1$

W_2 = Final mean weight W_1 = Initial mean weight

Percentage weight gain (PWG) = (Mean weight gain/Mean fish weight) × 100

Specific growth rate (SGR) = 100 $(W_2 - W_1)/T$

W_2 = Final mean body weight W_1 = Initial mean body weight

T= Duration period in days

Feed conversion ratio (FCR) = Feed intake/Weight gain

Protein efficiency ratio (PER) = (Final mean body weight – Initial mean body weight)/Feed supplied × Dietary crude protein

Survival rate=No of fish at the end of the experiment/Total no of fish at the onset of the experiment×100

2.5 Statistical analysis

The statistical analysis was performed using the general linear model function of Statistical Package for Social Science (SPSS), version 16.0. All data generated were subjected to One-Way ANOVA while statistical differences between treatments were determined using Duncan's Multiple Range test.

3. Results

3.1 Proximate composition of co-fungal treated rice bran

Table 1 presents the proximate composition of co-fungal treated rice bran. The percentage of crude protein and ash content of untreated rice bran increased significantly from 12.13 to 19.72% and from 12.45 to 23.34%, respectively, in co-fungal treated samples. The crude fiber decreased by 38.53% in the co-fungal treated sample when compared with the untreated sample.

3.2 Gross composition of experimental diets

The gross composition of the control diet without the inclusion of co-fungal treated rice bran is shown in Table 2, while Table 3 shows different inclusion levels of co-fungal treated rice bran in the formulated diets. Each of the experimental diets had a total weight of 3 kg irrespective of the treatment or inclusion.

The proximate compositions of formulated diets are presented in Table 4. In terms of percentage moisture in each of the formulated diets, control diet T1 (D_0) had the highest moisture content of 10.46% followed by T5 (D_{50U}), T4 (D_{50T}), T3 (D_{20U}) at 8.38, 7.24 and 5.52%, respectively, while the lowest moisture content of 5.16% was observed in T2 (D_{20T}). The percentages of crude fiber in diets T1, T2, T3, T4, and T5 were 3.55, 17.60, 13.88, 8.73, and 9.62%, respectively. This shows that the crude fiber in the control diet was significantly below the levels in the other diets. It is also observed that the 20 percent inclusion treated diet T2 (D_{20T}) had more crude fiber than the 50 percent inclusion treated diet T4 (D_{50T}) at $p < 0.05$. In all the isonitrogenous diets formulated, 50 percent inclusion co-fungal treated diet T4 (D_{50T}) had the highest (15.23) fat content, followed by 50 percent inclusion untreated diet T5 (D_{50U}) at 13.85, while the lowest level was for 20 percent inclusion of untreated T3 (D_{20U}).

3.3 Growth performance of *C. gariepinus* fed with formulated dietary treatments

Growth parameters, feed utilization, and percentage survival rate of *C. gariepinus* fed with different experimental diets for 58 days are shown in Table 5. The survival rate was highest with the control diet T1 (D_0) and with T2 (D_{20T}) at 80%, followed by T3 and T5 (D_{50T}), while experimental group receiving 50 percent co-fungal treated diet T4 (D_{50T}) had the poorest approximately 53% survival rate. There was no significant difference in the initial mean weight across the treatment groups before the introduction of experimental diets ($p<0.05$). The highest mean final weight of 144.70 g occurred in *C. gariepinus* fed with the control diet (T1 (D_0)), followed by T3 (D_{20U}), T2 (D_{20T}), T5 (D_{50U}) in rank order, while the lowest mean final weight of 56.51 g was observed in T4 (D_{50T}). There was significant variation in the weight gain by treatment. The highest weight gain was observed with treatment T1 (D_0) at 84.312 g, followed by T3 (D_{20U}), T2 (D_{20T}), T5 (D_{50U}) at 42.88, 41.74, and 31.83 g, respectively, while a loss of -4.02 g in weight was recorded for treatment

Table 1. Proximate composition of co-fungal treated rice bran (%)

Treatments	Moisture	Ash	Crude fiber	Protein	Fat
a	10.55^{c}±0.05	12.45^{a}±0.41	34.33^{c}±0.35	12.13^{a}±0.20	0.92^{a}±0.20
b	7.30^{a}±0.26	21.58^{b}±0.30	24.60^{b}±0.53	12.77^{b}±0.08	4.06^{b}±0.19
c	8.89^{b}±0.10	23.34^{c}±0.26	21.10^{a}±0.22	19.72^{c}±0.49	7.63^{c}±0.34

a-before co-fungal treatment, b-during co-fungal treatment, c-after co-fungal treatment

Table 2. Gross Composition (g/100g dry matter) diet control without the inclusion of co-fungal treated rice bran

Ingredient	% Incorporation	Feed incorporation in kg
Fishmeal	25	3.75
Soybean meal	40	6.00
Yellow maize	15	2.23
Groundnut cake	10	1.50
Vit./Min. premix	3	0.45
Vegetable oil	4	0.60
Binder	2	0.30
Bone meal	1	0.15
Total	100	15.00

vitamin mix and mineral mix; provides per kilogram of diets : vitamin A, 10,000 IU; vitamin D3, 2,200 IU; vitamin E, 10mg; vitamin K3, 2mg; Folic acid, 0.5mg; vitamin B12, 10µg; vitamin B1, 1.5mg; biotin, 20mg, antioxidant, 125mg; selenium, 200mg; iodine, 1000mg; iron, 40,000mg; cobalt, 2mg; manganese, 70mg; copper, 4mg; zinc, 50mg;choline chloride, 150mg

Table 3. Compositions of all the experimental diets

Item	D_0	D_{20T}	D_{20U}	D_{50T}	D_{50U}
Fermented rice bran (%)	-	20	-	50	-
Untreated rice bran (%)	-	-	20	-	50
Commercial fish feed (kg)	3.00	2.40	2.40	1.50	1.50
Inclusion (kg)	-	0.60	0.60	1.50	1.50

T4 (D_{50T}). There was a significant difference in protein intake between the treatments. The protein intake between the treatments ranged from -4.34 in treatment T4 (D_{50T}) to 10.87 in treatment T1 (D_0), showing that the control diet gave the highest protein intake. Furthermore, the feed conversion ratio was highest in T5 (D_{50U}) at 0.70, followed by T3 (D_{20U}) (0.59), T2 (D_{20T}) (0.55), and T1 (D_0) (0.33), while the lowest value was observed for T4 (D_{50T}) at -4.65. The protein efficiency ratio had its maximum at 0.08 for the control diet (T1 (D_0)), while the lowest value of -0.01 was recorded for T4 (D_{50T}).

3.4 Carcass composition of *C. gariepinus* fed with formulated diets

From Table 6, there was a significant reduction in the moisture content of the carcasses after completion of the experiment when compared with the experimental fish before feeding trials. The moisture contents in the carcasses from different treatments ranged from 7.12 in T3 (D_{20U}) to 11.88 in T2 (D_{20T}). The percentage crude protein in the carcasses of T1, T2, T3, and T4 increased by 10.58, 11.03, 6.74, and 14.34%, respectively, while a 4.66% decrease in protein content was observed for T5 in comparison with the experimental fish before exposure to experimental diets. Carcasses from treatment T4 (D_{50T}) had the highest crude protein level of 49.05%, while the least level of 40.90% was obtained from T5 (D_{50U}). The fat contents in the carcasses from all the treatments where higher when compared with the experimental fish before feeding trials. The highest fat content of 10.13% was recorded for treatment T1 (D_0), while T2 (D_{20T}), T3 (D_{20U}), T4 (D_{50T}), and T5 (D_{50U}) had 12.05, 13.91, 7.28, and 8.58%, respectively. The ash contents in T1 (D_0), T2 (D_{20T}), T3 (D_{20U}), T4 (D_{50T}), and T5 (D_{50U}) were 15.18, 14.11, 17.80, 16.63, and 14.46%, respectively, with the highest ash content for T3 (D_{20U}). The ash contents in the carcasses from all the treatments were higher values when compared with the experimental fish before the feeding trial.

4. Discussion

In this study, two fungal strains with good hemicellulolytic profiles (Olaniyi & Akinyele, 2014) degraded

Table 4. Proximate compositions of experimental diets (% dry matter)

Parameter	TI (D_0)	T2 (D_{20T})	T3 (D_{20U})	T4 (D_{50T})	T5 (D_{50U})
Moisture content	10.46^{d}±0.37	5.52^{a}±0.21	5.16^{a}±0.09	7.24^{b}±0.23	8.38^{c}±0.41
Ash content	8.75^{a}±0.16	14.94^{c}±0.67	15.78^{d}±0.20	11.97^{b}±0.44	11.93^{b}±0.49
Fat content	9.18^{b}±0.49	7.02^{a}±0.46	7.84^{a}±0.44	15.23^{d}±0.38	13.85c±0.67
Crude fibre	3.55^{a}±0.23	13.88^{d}±0.29	17.60^{e}±0.47	8.73^{b}±0.31	9.621^{c}±0.54

Means with the different superscripts within a row are significantly (p<0.05) different

Table 5. Growth performance and feed utilization parameters

Growth Parameters	Diets				
	T1 (D_o)	T2 (D_{20T})	T3 (D_{20U})	T4 (D_{50T})	T5 (D_{50U})
Experimental period (days)	58	58	58	58	58
Number of animal	15	15	15	15	15
Survival rate (%)	80	80	66.67	53.33	66.67
Initial mean weight (g)	60.34^{a}±0.34	60.15^{a}±0.11	60.45^{a}±0.39	60.53^{a}±0.11	60.60^{a}±0.34
Final mean weight (g)	144.70^{d}±4.17	101.89^{c}±1.49	103.33^{c}±0.60	56.51^{a}±1.19	92.43^{b}±1.02
Weight gain (g/week)	84.312^{d}±3.83	41.74^{c}±1.43	42.88^{c}±0.99	-4.02^{a}±1.32	31.83^{b}±1.36
Percentage weight gain (%/week)	2.40^{d}±0.06	1.69^{c}±0.03	1.71^{c}±0.02	-0.93^{a}±0.02	1.53^{b}±0.03
Specific growth rate (%/week)	200.76^{d}±9.13	99.37^{c}±3.40	102.09^{c}±2.35	-9.71^{a}±3.15	75.80^{b}±3.25
Protein intake	10.87^{e}±0.31	7.44^{d}±0.18	6.64^{c}±0.26	-4.34^{a}±0.06	5.71^{b}±0.23
Feed conversion ratio (FCR)	0.33^{b}±0.10	0.55^{b}±0.02	0.59^{b}±0.02	-4.65^{a}±1.67	0.70^{b}±0.03
Protein efficiency ratio	0.08^{d}±0.00	0.06^{b}±0.00	0.07^{c}±0.00	-0.01^{a}±0.00	0.06^{b}±0.00

Means with the different superscripts within a row are significantly (p<0.05) different.

Table 6. Carcass compositions of experimental fish

Parameter (%)	Before experiment	After experiment				
		T1 (D_0)	T2 (D_{20T})	T3 (D_{20U})	T4 (D_{50T})	T5 (D_{50U})
Moisture	46.98	10.13^{c}±0.08	11.88^{e}±0.37	7.12^{a}±0.10	11.00^{d}±0.02	8.47^{b}±0.33
Crude protein	42.90	47.44^{c}±0.84	47.63^{c}±0.00	45.79^{b}±1.00	49.05^{d}±0.89	40.90^{a}±0.00
Fat	2.92	17.01^{e}±0.68	12.05^{c}±0.29	13.91^{d}±0.44	7.28^{a}±0.51	8.58^{b}±0.02
Ash	4.61	15.18^{b}±0.04	14.11^{a}±0.58	17.80^{d}±0.33	16.63^{c}±0.23	14.46^{a}±0.30

Means with the different superscripts within a row are significantly (p<0.05) different.

and improved the nutritive values of rice bran. On this basis, co-fungal treated rice bran was evaluated as a substitute for fish meal. Rice bran is reported as a plant ingredient that is extensively used in formulations of aquaculture diets, serving as a protein and carbohydrate source (Muin, Abdul Fatah, Bahari, & Abdul Razak, 2014; Kemigabo *et al*., 2018). Its protein, lipid, ash, and total phosphorus contents generally are 11-14%, 12-18%, 7-14%, and 1.5%, respectively (Kemigabo *et al*., 2018; Wataniyakul, Pavasant, Goto, & Shotipruk, 2012). The crude protein of co-fungal treated rice bran in this study was approximately 20%, which is similar to the report of Muin *et al*. (2014) according to which feed ingredients containing 20% crude protein or more are good candidates for feed formulation. The potential of microbiologically modified or enriched agricultural wastes as stock-feed has been investigated extensively in the past (Gélinas & Barrette, 2007; Ghaly, Kamal, & Correia, 2005; Ke *et al*., 2011; Stabnikova, Wang, Din, & Tay, 2005). Filamentous fungi have been reported to biodegrade varieties of agricultural wastes through the secretion of extracellular enzymes (phytases, xylanases, cellulases, mannanases, lipases, pectinases, proteases, and so on) (Akinyele & Agbro, 2008). The co-fungal fermentation technique has been documented to have an edge over the mono-culture systems with speedy bioconversion and improved end products (Ke *et al*., 2011; Parani & Eyini, 2012). Improvement in the nutritive values of co-fungal treated agricultural wastes had been attributed to synergistic action exhibited by the organisms involved (Parani & Eyini, 2012). Also, predigesting fiber compounds via secreted enzymes increases the bioavailability of essential nutrients for target microorganisms either in form of carbon or nitrogen sources, and consequently causes an increase in nutritive protein biomass (Olaniyi, 2014). In many cases, bioconversion has led to the formation of nutraceutical and functional foods or feeds vital for livestock and fish farming.

The conversion of feed to fish flesh implies that the nutrient content in the feed is well utilized. The result of this study was not in support of findings reported by many researchers that have evaluated the effect of partial or absolute substitution of fish meal with either fermented wastes or single-cell proteins. At all levels of inclusion, a reduction in weight gain was recorded when compared with the control diet. Higher growth obtained from the control diet may be attributed to the fact that fish meal provided superior and better nutritional values than co-fungal fermented and unfermented rice bran in experimental diets. According to previous studies, fish meal is rich in protein, essential minerals (e.g. calcium and phosphorus), and energy. In addition to this, it is also a primary source of vitamins such as biotin, chlorine, and vitamins A, B_{12}, D, and E, and includes microelements like iodine and selenium. The nutritional quality might be ascribed to the presence of essential amino acids, and long-chain polyunsaturated omega-3 fatty acids (Ayssiwede *et al*., 2016; Davidsona *et al*., 2016; Olsen & Hasan, 2012). All these parameters might account for the superiority of the control diet over the diets containing varying inclusions of untreated and fungal-treated rice bran. The results may also be attributed to acceptability, palatability, and digestibility of the feed. Bob-Manuel and Alfred-Ockiya (2011) reported an appreciable growth over the control diet when *Oreochromis niloticus* was fed with 50 percent yeast SCP diet, while Mondal, Kaviraj, and Mukhopadhyay (2012) reported improved growth when 65 percent fish meal was substituted for with fermented mulberry leaf (*Morus indica*) meal in the diet of Indian minor carp *Labeo bata*. The reduction in the growth of *C. gariepinus* fed with co-fungal treated rice bran might be due to the presence of residual anti-nutrient compounds and the addition of toxic fungal biomass to the sample during fermentation (Parani & Eyini, 2012). Improved weight gain with the control diet when compared with fungal treated and untreated rice bran inclusions could be linked to the ease of absorption of the important nutrients present in the diet. Feed conversion ratios obtained in this work are lower than those reported by Davies and Wareham (1988), El-Saidy and Gaber (2012), Belal and Al-Owafeir (2004), and Bob-Manuel and Alfred-Ockiya (2011). Similarly, the FCR of the experimental diets in this study were lesser than the values reported by El-feky *et al*. (2017) for African catfish *C. gariepinus* (Burchell, 1822) fed with different graded levels of local yeast, with values of 1.6 and above. Amisah, Oteng, & Ofori (2009) also reported higher FCR for juvenile African catfish, *C. gariepinus* fed with *Leucaena leucocephala* diets for 90 days. Some of these discrepancies may have arisen from differences in species as well as the culture systems. The results of the present investigation showed that the control diet was more suitable than the diets formulated from co-fungal fermented and unfermented rice bran in a practical diet for *C. gariepinus* to replace fishmeal.

The fat level in the carcass composition of *C. gariepinus* increased with inclusion level of co-fungal fermented and unfermented rice bran in the formulated diets. However, the fat content of fish fed with the control diet was significantly higher than with any of the inclusion diets. The reason for the high body lipid might be an attempt by the fish to deaminate protein in which the ammonia was eliminated as a by-product and the non-nitrogenous or carbonaceous portion of the diet deposited as fat (Mondal *et al*., 2012). This may have occurred in the preparation for breeding as the fish will stop feeding and rely solely on the deposited fat especially in the maternal mouth-brooders like *C. garipienus* (Mondal *et al*., 2012). It has been reported by Ke *et al*. (2011) and

Aboaba (1990) that accumulated lipid serves as an index of spawning preparation, as may be the case with the fish in this study. Some authors (Bob-Manuel & Alfred-Ockiya, 2011; Chang, Huang, & Liao, 1988) reported that brood fish may require elevated protein and fat levels to increase reproductive efficiency. The lipid values in this work are higher than those reported by Davies and Wareham (1988), El-Saidy and Gaber (2002), Attack and Matty (1979), Sogbesan, Ajuonu, Madu, Omojowo, and Ugwumba, (2004), and Ozório *et al*. (2010). It has been observed that carp fed on single-cell protein diets had low lipids in their gross carcass composition, which is contrary to the findings of the present investigation. The ash content in the test fish body increased compared to the value in the initial fish carcass before the treatments. The moisture content also decreased with the treatments compared to the control diet as well as to the initial fish carcass. Low moisture content obtained in the fish carcass is a yardstick of good growth as noted by Odedeyi (2014). The result of the carcass analysis of the fish showed that diet T2 (D_{20T}) (20% fishmeal substituted co-fungal fermented rice bran) gave the highest body protein value in *C. gariepinus* but not significantly higher than the control. This is an indication that the T2 (D_{20T}) competes well with the control diet.

5. Conclusions

In conclusion, partial replacement of fish meal with co-fungal fermented and unfermented rice bran in the diet of *C. garipienus* did not compete well with the control diet in terms of growth and nutrient utilization. However, there was an improvement in the carcass composition of the fish fed with the diets containing 20 and 50% co-fungal treated rice bran. Testing other potential plant protein sources that have been successful in other fish species is therefore suggested for further feeding trials of *C. garipienus*.

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