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Growth Performance and Nutrient Utilization of African Catfish Fed Yeast Fermented Shrimp Head Meal in Replacement for Fish Meal

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Abstract

Yeast fermented shrimp head meal was used to replace the more expensive fish meal (FM) to reduce costs of production and improve the profit margin. Shrimp head waste was fermented with yeast for 24 hours and used to replace FM at 0, 10, 20, 30 and 40% making up five treatments The diets were fed to fingerlings of *C. gariepinus* (5.61±0.04g) to apparent satiation for 70 days. The results showed that the growth performance of fish fed diet of 100% fish meal and the groups fed diets containing 10%, 20%, 30% fermented shrimp head waste meal was not statistically significant (P>0.05) with 30% replacement level having the best performance. The growth performance showed a declining trend with the fish fed diet containing 40% of the shrimp head meal. However, replacement of fish meal with the shrimp head waste meal did not affect the blood profile (P>0.05) of the fish. Differences in the carcass amino acid levels were marginal indicating that physiological functions might not have been compromised. In conclusion, yeast fermented shrimp head meal can replace up to 30% of FM in the diets of African catfish while the optimal level of replacement is 20% as indicated by the regression analysis.

Keywords: Shrimp head waste, yeast fermentation, fish meal, African catfish.

Introduction

The significance of animal protein in fish diets cannot be over-emphasized as it supplies essential amino acid required for fast growth, nourishment and maintenance of physiological functions (Nwanna *et. al.,* (2019). Conventionally, fish meal is used in fish diets because it contains the essential amino acid needed by fish in a balanced proportion. Availability and costs of fish meal vary across nations. In some countries, it is so scarce and expensive that identification of alternative protein substitutes is a priority in fish nutrition research (Nwanna, 2003). In Nigeria, because of high costs of fish meal, the cost of fish feed alone constitute over 60% of the running cost of aquaculture (Fagbenro, 1999); and this has strong limitations on the scope and expansion of aquaculture business (Nwanna, 2002).

Replacement of fish meal with ingredients of either vegetable or animal origin in fish feed (non-conventional sources) is necessary because of rising cost and unavailability of fish meal (Higgs *et al.*, 1995). Therefore, such alternative feed

ingredients must be cheap, readily-available and can fit exactly into the role played by fish meal in fish feeds (Nwanna, 2003).

A possibility is the use of shrimp head (waste) meal, which contains high levels of protein with excellent amino acid profile comparable to that of fish meal (Meyers, 1986). But the utilization of available protein in shrimp head meal by fishes is limited by the presence of substantial quantity of exoskeletal chitin and ash (Bhuiyan, 1989).

According to Balogun and Akegbejo-Samsons, 1992 about 1.6 x 10^4 MT of shrimp head waste (*Penaeus spp*) are generated annually in Nigeria and discarded as wastes and close to 2.8 x 10^5 MT from shrimp companies around the world (Fox *et al.,* 1994). Continued production of the shrimp head waste without corresponding appropriate technology to utilizing the wastes has resulted in waste accumulation, disposal and pollution problems (Nwanna *et al*., 2004).

Harnessing of these wastes into fish feed production apart from minimizing the costs of fish production would serve as an excellent means of sanitizing the environment. (Nwanna *et al*. 2004).

Therefore, this study determined the chemical composition of yeast fermented shrimp head waste meal and the replacement value for fish meal in the production of African catfish, *Clarias gariepinus*.

Materials and Methods

Collection of sample

Fresh shrimp waste (comprising mainly heads of *Penaeus notialis*, *Penaeus duorarum, Parapenaeus longirostris* and *Penaeus kerathurus*) were collected from Makoko fish market, Makoko, Yaba, Lagos and transported in frozen blocks to the Federal University of Technology, Akure, Fisheries Laboratory. Fish feedstuffs, fish meal, soybean, carbonxymethyl cellulose, fish and vegetable oils, vitamin - mineral premix, methionine, yellow maize, were purchased from a reputable outlet in Akure. Also hatchery bred *Clarias gariepinus* (5.61±0.04g) fingerlings were bought from a reliable farm in Akure and transported in oxygenated polythene bags to the Fisheries Laboratory of Federal University of Technology, Akure. The fish was acclimatized for 14 days in tanks before used in the feeding trials.

Preparation of silage meal

Seventeen (17) kilograms of fresh shrimp head waste was weighed and 85g of yeast (*Saccharomyces cereevisae*) was added (5gram of yeast to 1kilogram of shrimp), it was mixed thoroughly and allowed to ferment for 24 hours in an air tight plastic container. It was sundried thereafter and the dried product was ground into fine powder to form the silage meal according to Fagbenro and Jauncey (1995) and stored at -20℃ prior to use.

Formulation of experimental diets

Five isonitrogenous diets (40% crude protein) were formulated, containing increasing levels of the shrimp head waste silage meal at 0% (control), 10, 20, 30 and 40% making up five different diets (1-5) according to standard procedure. These were mixed thoroughly with other ingredients in a homogeneous mass. Carboxymethyl cellulose and hot water were added and mixed further to obtain a dough-like paste. The diet mixtures were then extruded through a 2-mm die mixer (Hobart A-200T) pelleting machine to form model-like strands which were mechanically broken into pellets of suitable size for *Clarias gariepinus* fingerlings. The pelleted diets were sun-dried at 31-32 ^{o}C and stored at -20 ^{o}C in air-tight polyethylene bags prior to use.

Feeding trials

The experimental was a completely randomized design involving five treatments with three replicates each. A total of fifteen tanks were used. Ten fish (5.61±0.04g) were randomly stocked in each tank and fed to apparent satiation twice daily for 70 days. Fish in each tank was weighed bi-weekly to measure the growth performance. Water parameters were constant at temperature 27 - 30 ^{o}C; dissolved oxygen 6.5-8.3 mg/L and pH 6.0 - 8.5 throughout the experiment. After 70 days, the fish in each tank was counted and weighed. Fish performance evaluation was carried out using the following indices as described by Nwanna (2002). Mean weight gain (MWG), MWG =W_F-W_I. Where; W_F = Final weight, W_I= Initial weight. Specific Growth Rate (SGR), SGR % = Log_e Final – log_e Initial weight/ culture period x100. Feed conversion ratio (FCR) = Total feed intake/ Total weight. Gross feed conversion efficiency (GFCE): = 1/ FCR X 100. Protein Intake (PI), = feed intake

x crude protein in the diet. Protein Efficiency Ratio (PER), PER = MWG/Mean PI.

Proximate composition and blood analyses

Proximate analyses of the feed, faeces and fish carcass were carried out according to AOAC (2006) methods. A fish specimen was removed from each glass tank for blood analysis. 5 ml of blood from fish in each treatment group was collected by cardiac puncture using different 5 ml disposable heparinized syringes, with ethylene diamine tetra acetic acid (10ml EDTA) as anti-coagulant. The blood was stored at -4^{0}C prior to analysis. The blood analysis followed the methods described by Svobodova *et al.,* (1991).

Determination of Amino Acid Profile

The Amino Acid profile of the fish carcass (whole body) was determined using methods described by Benitez (1989). A known sample was dried to constant weight, defatted, hydrolysed, evaporated in a rotary evaporator and loaded into the Applied Bio-systems PTH Amino Acid Analyser. An integrator attached to the Analyser calculated the peak area proportional to the concentration of each of the amino acids.

Statistical Analysis

Biological data resulting from the experiment were subjected to one-way analysis of variance using the SPSS (Statistical Package Computer, Software 1998 Version, Chicago Illinois, USA). Duncan's multiple range test was used to compare differences among individual means at (P=0.05) (Duncan, 1955).

Results

The proximate composition of the experimental diets (Table 2) indicated that addition of the fermented shrimp head waste meal (SHM) in the diets caused significant increase in the moisture and ash contents of the diets. The reason for increase in moisture is not known yet, but the large ash content may be ascribed to high ash content of the shrimp head meal. While the lipid content decreased significantly with increasing levels of the fermented shrimp head waste meal. The crude fibre also increased significantly with increasing levels of the SHM, whereas there were no significant differences in the protein and carbohydrate contents of the diets. However, the carbohydrate decreased marginally with increasing levels of the SHM in the diets.

Table 1: Gross composition of the experimental diets (40% CP)/ (g/100g) for African catfish

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Menhaden fish meal (65%CP)	39.0	35.1	31.2	27.3	23.4
Shrimp head waste meal (45%CP)	0.00	5.63	11.3	16.9	22.5
Soybean meal (45%CP)	32.5	32.5	32.5	32.5	32.5
Yellow maize	17.96	16.23	14.46	12.76	11.06
Cod liver oil	5.00	5.00	5.00	5.00	5.00
Vitamin – mineral mix	2.54	2.54	2.54	2.54	2.54
Methionine	2.00	2.00	2.00	2.00	2.00
Carboxymethycellulose	1.00	1.00	1.00	1.00	1.00

Table 2: Proximate composition of experimental diets

Parameter	Control	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Moisture (%)	7.47±0.09^a	9.95±0.38^d	8.25±0.19^b	9.54±0.19^{cd}	9.09±0.10^c
Ash (%)	10.00±0.00^a	13.00±0.58^b	14.00±0.00^b	13.00±0.58^b	13.00±0.58^b
Lipid (%)	13.00±0.58^b	13.00±0.58^b	12.00±0.00^b	10.00±0.00^a	10.00±0.00^a
Protein (%)	42.41±0.02^a	42.40±0.02^a	42.14±0.02^a	41.86±0.02^a	41.52±0.08^a
Crude fibre (%)	1.20±0.01^b	1.83±0.00^c	1.87±0.00^d	1.92±0.00^e	1.95±0.03^a
NFE (%)	25.93±0.48^b	23.90±0.36^a	23.74±0.21^a	23.68±0.37^a	23.33±0.52^a

NFE - Nitrogen Free Extract

Amino acids composition of the experimental diets (Table 3) indicated that replacing fish meal with yeast fermented shrimp head meal did not significantly affect the dietary amino acids composition of the diets. Similarly, no clear trend was exhibited by the various values. Sometimes the values from diet with 100% FM are higher than those of the diets containing fermented shrimp head meal. In some cases, diets containing the SHM had higher values than the diet with 100% FM. Also, even the diets supplemented with the four levels of the SHM did not show any clear line of inclination in the amino acid values, indicating that the diets were equally good.

The growth and nutrient utilization indices (Table 4) showed no significant differences in the final mean weight of fish fed diets containing 0, 10, 20 and 30% (diets 1-4) of the SHM.

Meanwhile, the fish fed diets 1-4, had significantly better final mean weight than the fish fed diet with 40% of the SHM (diet 5). The mean weight gain and specific growth rate followed the same trend as in the mean final weight gain of the fish fed the different diets. The growth performance also showed an increasing trend from fish fed diet 1 up to fish fed diet 3 and then a decline. However, there were no significant differences in the food conversion and protein efficiency ratios of the fish fed the five different diets. The table also showed that diets 1-3 stimulated more appetite in the fish than diets 4 and 5. This made the fish in treatments 1-3 to consume more ($P<0.05$) food than those in treatments 4 and 5. While the growth performance was highest in fish fed diet with 30% shrimp head meal, Fourth degree polynomial regression analysis showed 20% as the optimal replacement level (Figure1).

The carcass composition of the fish (Table 5) showed decreasing levels of moisture with increasing levels of SHM in the diets. The carcass protein increased with increasing levels of SHM in the diets. As observed earlier presence of the SHM increased the dietary moisture, opposite observation

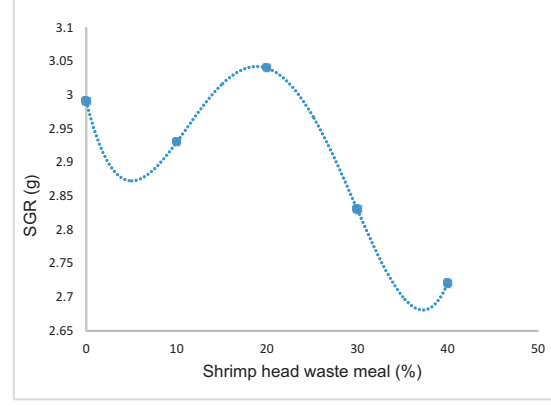

Figure 1: Fourth degree order polynomial regression analysis

Table 3: Amino acid composition (EAA, NEAA g/100g/protein) of experimental diets

AA (FEED)	control	T1	T2	T3	T4
Leucine	6.77	6.13	6.83	9.90	6.71
Lysine	4.88	4.53	5.04	4.35	4.64
Isoleucine	3.60	3.41	3.80	3.41	3.47
Phenylalanine	4.43	3.90	4.43	3.55	3.99
Valine	3.68	3.39	3.86	3.27	3.56
Methionine	2.27	2.19	2.30	2.22	2.24
Arginine	5.59	5.33	6.02	4.99	5.51
Histidine	2.24	2.20	2.36	2.17	2.30
Threonine	3.39	3.30	3.36	3.48	3.55
Cystine	1.33	1.31	1.33	1.33	1.29
Alanine	4.29	3.91	4.32	3.49	4.10
Glutamine acid	12.2	12.0	12.6	11.9	11.8
Glycine	3.52	3.42	3.71	3.18	3.56
Serine	3.00	2.92	3.24	2.81	3.08
Aspartic acid	8.84	8.25	8.90	8.25	8.68
Proline	3.35	3.25	3.35	3.25	3.25
Tyrosine	3.27	3.10	3.27	2.92	3.35

Table 4: Growth of *C. gariepinus* fed shrimp head waste meal fermented with yeast

Parameter	Control	Treatment 1	Treatment 2	Treatment 3	Treatment 4
IMW	5.61±0.04^{a}	5.65±0.02^{a}	5.69±0.04^{a}	5.67±0.06^{a}	5.63±0.03^{a}
FMW	45.34±0.96^{b}	45.80±1.70^{b}	47.75±2.16^{b}	41.11±2.20^{ab}	38.08±2.95^{a}
MWG	39.73±0.98^{b}	40.20±1.69^{ab}	42.05±2.18^{b}	35.57±2.03^{ab}	32.45±2.96^{a}
SGR	2.99±0.04^{b}	2.93±0.05^{ab}	3.04±0.07^{b}	2.83±0.06^{ab}	2.72±0.11^{a}
ADG	0.57±0.02^{b}	0.55±0.02^{ab}	0.60±0.03^{b}	0.51±0.03^{ab}	0.46±0.04^{a}
FCR	1.26±0.03^{a}	1.37±0.08^{a}	1.26±0.01^{a}	1.42±0.08^{a}	1.38±0.08^{a}
GFCE	79.30±1.60^{a}	73.40±4.27^{a}	79.38±0.59^{a}	70.59±3.72^{a}	72.52±4.06^{a}
PER	1.87±0.04^{ab}	1.87±0.06^{ab}	2.04±0.07^{b}	1.83±0.08^{ab}	1.75±0.18^{a}
Feed Intake	16.70±1.41^{c}	16.12±3.86^{bc}	16.27±3.11^{bc}	15.47±2.37^{ab}	14.85±5.20^{a}

Means of 3 values on the same row with different superscripts are significantly (P<0.05)

Table 5: Carcass composition of *C. gariepinus* fed experimental diets

Parameter	Control	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Moisture	10.33±0.19^{c}	9.34±0.67^{abc}	9.83±0.10^{bc}	8.15±0.10^{a}	8.80±0.43^{ab}
Ash	12.67±0.67^{b}	11.67±0.33^{ab}	12.00±0.58^{ab}	11.67±0.33^{ab}	11.00±0.00^{a}
Lipid	10.16±0.53^{ab}	10.85±0.69^{b}	9.21±0.08^{ab}	8.29±0.92^{a}	9.08±0.81^{ab}
Protein	66.85±0.02^{a}	68.14±0.07^{a}	70.12±0.11^{b}	71.89±0.95^{b}	71.96±0.02^{b}

Table 6: Haematological profile of *C. gariepinus* fed experimental diets

Parameter	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
PCV	26.00 ± 3.79^{a}	25.7± 2.19^{a}	25.3±3.84^{a}	24.3±4.333^{a}	23.7±2.03^{a}
HB	8.70 ± 1.29^{a}	7.57±0.72^{a}	7.10±1.27^{a}	7.13±1.44^{a}	7.97±0.70^{a}
RBC	2.92±0.42^{a}	2.88±0.24^{a}	2.67±0.41^{a}	2.38±0.46^{a}	2.35±0.23^{a}
WBC	5.97±1.15^{a}	8.83±2.3^{a}	8.23±9.9^{a}	7.03±1.3^{a}	6.93±0.60^{a}
N	62.3±1.45^{a}	70.3±1.76^{a}	68.0±5.29^{a}	64.0±5.51^{a}	61.7±2.91^{a}
L	36.33±1.67^{a}	26.00±2.65^{a}	28.67±6.84^{a}	33.67±6.84^{a}	37.0±7.21^{a}
M	2.00±0.00	2.33±0.33	2.00±0.000	2.00±0.00	3.00±0.00
E	2.00±0.00	2.00±0.00	2.00±0.000	2.00±0.00	2.50±0.50
MCV	89.12±0.12^{a}	88.37±0.54^{a}	88.14±1.86^{a}	89.16±0.91^{a}	88.77±0.12^{a}
MCHC	33.45±0.13^{a}	33.41±0.08^{a}	33.32±0.18^{a}	33.45±0.07^{a}	33.65±0.08^{a}
MCH	29.81±0.10^{a}	29.53±0.13^{a}	29.36±0.46^{a}	29.87±0.27^{a}	29.87±0.07^{a}

Means of 3 values on the row with similar superscripts are not (P>0.05),
PCV- pack cell volume, HB –haemoglobin, RBC- red blood cell, WBC- white blood cell, N –neutrophile, L-leucophile, M-monophile, E-eosinophile, MCV-mean corpuscular volume, MCHC-mean cell haemoglobin concentration, MCH- mean corpuscular haemoglobin.

is recorded with the carcass moisture, and there may be further studies to explain this trend in moisture characterization. The higher protein deposition in all the fish fed diets with SHM as compared to fish fed diet without SHM may be attributed to the effect of fermentation in making protein more bioavailable to animals.

The blood profile of the fish after the experiment (Table 6) indicated no significant differences in all the parameters measured. All the values are in the normal range and did not indicate any clear pattern of increment/reduction. The PCV, Hb and RBC decreased slightly with increasing values of the SHM in the diets, and except the WBC, which

Table 7: Amino acid composition (g/100g/protein) of *C. gariepinus* fed experimental diets

	T1	T2	T3	T4	T5
Leucine	5.98	6.30	6.30	6.19	5.95
Lysine	6.95	7.50	7.66	7.27	6.87
Isoleucine	3.31	3.60	3.80	3.24	3.08
Phenylalanine	3.90	3.99	4.08	3.90	3.81
Valine	4.01	4.30	4.56	4.09	3.86
Methionine	2.22	2.19	2.27	2.24	2.19
Threonine	4.08	4.25	4.19	3.94	3.87
Arginine	5.68	5.68	5.85	5.16	5.33
Histidine	2.36	2.62	2.78	2.37	2.34
Cystine	0.85	0.91	0.90	0.85	0.85
Alanine	5.61	5.84	5.92	5.57	5.20
Glutamine acid	13.7	13.9	14.2	13.5	13.3
Glycine	6.39	6.70	6.77	6.41	6.21
Serine	3.38	3.59	3.94	3.40	3.33
Aspartic acid	9.30	9.36	9.58	9.09	8.90
Proline	3.96	4.26	4.47	4.16	3.86
Tyrosine	3.10	3.27	3.27	3.25	3.15

increased slightly with the increasing levels of the SHM, other values did not show any inclinational sequence. Summarily, addition of SHM in the diets did not affect the blood profile of the fish.

The carcass amino acids composition (Table 7) showed no significant differences in the carcass amino acids profile of the fish. Also no general trend was established, but some of the parameters indicated a slight decreasing trend with increasing levels of SHM in the diets. By and large, replacing FM with 40% of the SHM did not affect the amino acids composition of the fish. Most of the trends were similar to that of the dietary amino acids composition. In summary, replacing FM with SHM did not compromise physiological functions.

Discussion

The study investigated the effect of replacement of fish meal with shrimp head waste meal fermented with yeast on the production of African catfish *C. gariepinus* with a view to reducing the costs of aquafeeds and improve the profit margin. The proximate composition of the experimental diets are marginally ($P>0.05$) different which is in line with the report of Nwanna (2003) and also indicating that the diets were well prepared and equally good. However, the mean value of crude fibre obtained from the present study is lower than the values of 4.59 and 4.5 reported by Nwanna (2003) for *C. gariepinus* fed with lactic acid fermented shrimp head waste meal and from the values reported by Fagbenro and Jauncey (1995) after feeding *C. gariepinus* with fish silage blended with hydrolyzed feather meal. Also the crude protein and carcass ash obtained from the study compared favourably with the values obtained by Nwanna (2003) from feeding *C. gariepinus* with shrimp head meal fermented with lactic acid. The increase in the carcass protein as a result of increasing levels of shrimp head meal observed from the present study is in consonance with the reports of Plascencia-Jatomea (2014) and Raja *et al.,* (2014) who found increased protein in Nile tilapia and koi carp respectively fed diets containing shrimp head hydrolysate fermented silage meal.

The amino acid (AA) contents of the experimental diets are marginally higher than the AA requirements of *C. gariepinus* reported by Uys (1989). This is normal as the fish does not always digest and assimilate all the amino acids in the diets. This observation is in line that of Nwanna *et al.,* (2004) on the determination of the chemical composition of lactic acid fermented shrimp head meal. The values of the dietary AA from the

present study are also comparable with the AA values reported by Fagbenro and Jauncey (1995) from co-dried Lactic-acid fermented fish silage diets.

The increase in weight gain obtained indicates that the diets were capable of supporting growth. The mean value of FCR of 1.34 obtained from the present study is close to the value of 1.61 reported by Fagbenro *et al*., (1994) for *C.gariepinus* fed with lactic acid fermented fish silage meal diets. Also, SGR, FCR and PER with mean values 2.90, 1.34 and 1.87 obtained in the present study are close with the mean values of 2.58, 1.61 and 1.52 for SGR, FCR and PER respectively, reported by Fagbenro *et al*., (1994) for *C. gariepinus* fed with lactic acid fermented fish silage meal diets. Raja *et al*., (2014) reported that the growth parameters of koi carp decreased with increasing levels of shrimp waste meal in the diets. Similar observations were made by Ng *et al*., (2001) and Nwanna (2003) from fish fed with mealworm and shrimp head silage meal, respectively as a replacement for fish meal. The results of the present study which showed a decreasing growth performance with increasing SHM in the diets also corroborates the findings of Hidayat and Rustami (1979) who reported that reduction in growth performance and feed utilization of fish fed high levels of dietary silage may be partly due to the presence thiaminase in the silage that would cause vitamin B_1 deficiency. The optimum level of SHM of 30% obtained from the study is in line with the report of Srour (2009) who recommended 30% of shrimp head meal as the optimum in the diets of Nile tilapia. In another study involving feeding of common carp with shrimp head meal, Raja *et al.* (2014) recommended 50% of meal as the optimum.

Blood parameters are good bio-indicators or diagnostic tools to study the effects of diets on the organ function before manifestation of any disease conditions and thus providing vital information for health assessment and management of fish under culture (Nwanna and Helen, 2017). The values of the blood parameters obtained from the present study are similar ($P>0.05$) for all treatments which shows that replacement of fish meal with fermented shrimp head waste meal did not affect the blood profile of the fish. Nwanna *et al*., (2004) also reported no significant differences in the blood parameters of *C. gariepinus* fed lactic acid fermented shrimp head meal in replacement for the fish meal.

The amino acid profile of the fish from the present study is closely related to the values established by Fagbenro and Jauncey (1995) from feeding *C. gariepinus* with co-dried lactic-acid fermented fish silage diets. They concluded that protein utilization, digestibility and fish growth performance are a function of amino acids availability from the diets. Similarly, the amino acids level from this study supports the values reported by Nwanna *et al.* (2004) from *C. gariepinus* fed lactic acid fermented shrimp head meal diets.

In conclusion, yeast fermented shrimp head waste meal can replace up to 30% of fish meal in the diets of African catfish, *Clarias gariepinus.*

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