Use of Fermented Wheat (*Triticum spp*) Waste Meal in the Diet of *Clarias gariepinus* fingerlings

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Abstract. Fingerlings of *Clarias gariepinus* were stocked into ten tanks at ten fingerlings per tank and subjected to five treatments replicated twice. Fermented wheat waste meal, which was the test ingredient, was included at 0%, 20% 40%, 60% and 80% in five diets formulated at 40% crude protein. The experiment lasted for 70 days. Fish fed with diet D5 had the best growth rate with specific growth rate of 2.20±0.08, feed conversion ratio of 0.08±0.05 and protein efficiency ratio of 0.63±0.04 while fish fed with diet CTR had the least growth rate with specific growth rate of 1.73±0.21, feed conversion ratio of 1.26±0.29 and protein efficiency ratio of 0.41±0.09.
The cost of the experimental diets showed that the cost of production of 1kg feed reduced as the level of inclusion of the test diet increased. Hence, fermented wheat waste can replace maize as an energy source in the diet of *Clarias gariepinus* fingerlings up to 80% inclusion level without adverse effect on growth and nutrient utilization and this will also reduce the cost of production.

Keywords: fermented wheat waste meal, maize, *Clarias gariepinus*, growth, nutrient utilization, cost analysis .

INTRODUCTION

The rise in global awareness of fish as a valuable source of protein, has led to increased progress in aqua feeds production with diets being specifically designed to meet the nutritional requirements of species, life cycle and health conditions of fish (Craig and Helfrich, 2002, Rawling *et al*., 2012). The most popular fish species that has proved desirable for culture in Nigeria are the clariid fishes, *Clarias gariepinus*, “Heteroclarias” *spp* and *Heterobranchus spp*. (Adekoya *et al.*, 2006). The African catfish, *Clarias gariepinus* is an important species in the aquaculture industry throughout the world. The species have several advantages such as; good taste, fast growth, resistance to low oxygen and considerable ease in farming (Fagbenro *et al.*, 2005).

It is essential to ensure that adequate energy level is provided in fish diets so as to realize protein sparing effect and to ensure higher percentage of amino acids in protein being available for growth and other physiological function (Jimoh *et al.*, 2014). Maize is a cereal grain commonly used as carbohydrate or energy source in fish diet; however, competition for its use in human foods and animal feeds limits its availability and raises its price unlike wheat waste which is usually discarded after the main product of interest has been extracted. There is therefore the need to replace maize as a carbohydrate source in fish diet without compromising or affecting the health and growth of fish.
Wheat (*Triticum spp*) is a cereal grain, originally from the Levent region of the Near East but now cultivated worldwide (Anon., 2016a; Anon., 2016b). Globally, wheat is the leading source of vegetal protein in human food, having a higher protein content than other major

cereals, maize or rice (Anon., 2016b). Wheat belongs to the family Poaceae and genus Triticum (Anon., 2016a). In 2016, world production of wheat was 749 million tonnes (FAO, 2016a) making it the second most-produced cereal after maize (1.03 billion tonnes), with more than rice (499 million tonnes) (Anon., 2016b; FAO, 2016a). Wheat contributes essential amino acids, minerals, and vitamins, and beneficial phytochemicals and dietary fibre components to the human diet, and these are particularly enriched in whole-grain products, Its success depends partly on its adaptability and high yield potential but also on the gluten protein fraction which confers the viscoelastic properties that allow dough to be processed into bread, pasta, noodles, and other food products. However, wheat products are also known or suggested to be responsible for a number of adverse reactions in humans, including intolerances (notably coeliac disease) and allergies (respiratory and food) (Shewry, 2009).

Crude protein of wheat varies between 8-15% (Shewry, 2009). The presence of some anti-nutritional factors found in wheat like phytic acid, Estrogenic factor, protease inhibitor, Amylase inhibitor, Dihydroxyphenylalanine, Phytohaemagglutinins, flatulence factor (FAO, 2016b) could probably have effect on nutrient utilization and growth of fish. Processing of wheat by either fermentation or wet milling removes some of these anti-nutritional factors (FAO, 2016b). The processing of wheat produces some by-products among which is the fermented wheat waste.

Fermented wheat waste is gotten or extracted from using wheat for ‘’Ogi”, a common cereal gruel and staple food for several Yoruba communities in Nigeria. The chemical composition of fermented wheat waste is similar to that of maize, therefore its replacement for maize in the diet of fish is of research interest.

Maize (*Zea mays*) is a major source of energy in livestock and aqua feeds. It is highly competed for with the demand always exceeding the supply. The high competition for the use of maize makes it scarce and when it is available, it is very expensive thereby raising the cost of feed, which is already the highest running cost in livestock husbandry, hence the need to look into alternative feedstuff with little or no competition for its use. Fermented wheat waste is usually discarded after the gruel is removed therefore; there is little or no competition for its use.

MATERIALS AND METHODS

Feed formulation and preparation

The dietary ingredients: fish meal, soybean meal, maize meal, vitamin/mineral premix and methionine were procured from Metrovet Veterinary and Feed mill in Ado-Ekiti. Starch and vegetable oil were purchased from a local market in Ado-Ekiti, while the fermented wheat waste (FWW) was purchased from a local wheat gruel processor. Wet fermented wheat waste, which is a by-product of wet milling of wheat, was sun dried for two days to a moisture content of < 10% and milled using a milling machine into fine particles. It was then used to replace maize meal at 0%, 20%, 40%, 60% and 80% replacement levels in the experimental diet.

Diet D1 was the control and contained no fermented wheat waste (FWW). Diets D2, D3, D4 and D5 were formulated with FWW replacing maize at 20%, 40%, 60% and 80% respectively. The ingredients were mixed thoroughly with hot water to make it gelatinize. Starch was added to act as a binder before it was pelleted using Hobert A-200 pelleting machine with die size of 2.0 mm. The pellet was then sun dried and packed in well labelled air tight containers and stored in a cool and dry place.

Table 1. Gross composition of experimental diets

Ingredients	Diet CTR	Diet D2	Diet D3	Diet D4	Diet D5
Fishmeal (72%)	31.76	31.52	31.31	31.07	30.88
Soy bean meal (45%)	31.76	31.99	32.2	32.44	32.68
Maize meal (10%)	28.49	22.79	17.09	11.40	5.70
FWW (11.03%)	_	5.70	11.40	17.09	22.79
Methionine	0.4	0.4	0.4	0.4	0.4
Vitamins/Mineral Premix	4.0	4.0	4.0	4.0	4.0
Starch	1.1	1.1	1.1	1.1	1.1
Vegetable oil	2.5	2.5	2.5	2.5	2.5
Total	100	100	100	100	100
Crude Protein	40%	40%	40%	40%	40%

Growth Experiment

The experiment was carried out in the Teaching and Research Farm, Ekiti State University, Ado Ekiti using ten rectangular plastic tanks with dimension 70cm x 45cm x 40cm. The water level was maintained at $^{2}/_{3}$ level of the tanks throughout the period of the experiment. The source of water was an underground borehole at the Teaching and Research Farm of the University.

One hundred fingerlings of *Clarias gariepinus* were purchased from Afe Babalola University Farm in Ado-Ekiti. The fish were allowed to acclimate to the water condition for seven days in the plastic tanks before the commencement of the experiment. The fish were randomly stocked at the rate of ten fish per tank. Each treatment was replicated twice and the experiment lasted for 70 days during which five diets were fed to the fish in each corresponding tank within the period at 3% of their body weight twice daily at 08.00-09.00hours and 17.00-18.00 hours. The fish in each tank were weighed fortnightly and the weight recorded while the feeding rate was adjusted with respect to body weight every two weeks. Faeces and left over feeds were siphoned out every morning. Weight data collected were used to evaluate the performance of each diet.

Water quality assessment

Water parameters were measured fortnightly. Temperature was measured using a mercury-in-glass thermometer while dissolved oxygen was measured using dissolved oxygen metre. The pH was also monitored using a pH metre.

Biological evaluation

Diet performance was determined as follows:

i. Weight gain = final weight of fish (W2) - initial weight (W1)

ii. Specific growth rate (SGR) = $\frac{\ln \text{final W} - \ln \text{initial W} \times 100}{\text{Time period (Days)}}$

iii. Protein efficiency ratio (PER) = $\frac{\text{Fish weight gain (g)}}{\text{Protein consumed (g)}}$

iv Feed conversion ratio (FCR) = $\frac{\text{Weight of feed (g)}}{\text{Fish weight gain (g)}}$

Proximate Analyses

The proximate analyses of fermented wheat waste meal was determined and that of fish before and after the experiment using method of A.O.A.C. (1990)

Cost Analysis

The cost of producing 1kg of the different feeds where FWW was included at varying inclusion levels was calculated and compared with the production cost of 1kg of the control diet which has no FWW. Costing was done according to the prevailing market prices of ingredients that were used in the diets at the time of the experiment. The cost of producing 1kg of fish for each feed was also calculated.

Statistical analysis

The data collected from the experiment were subjected to one-way analysis of variance (ANOVA) using SAS package and the differences was separated using Duncan multiple range test (1955)

RESULTS

Proximate Analysis of Fermented Wheat Waste (FWW)

The result of the proximate analysis of fermented wheat waste (FWW) used in the experiment is given in Table 2. It has crude protein of 11.03% and ash content of 2.0%.

Table 2. Proximate Analysis of Fermented Wheat Waste

Crude protein	Ash	Lipid	Moisture	Crude fibre	NFE
11.03	2.00	1.20	13.00	5.28	67.49

Nutrient Utilization and Growth of Experimental Fish

Table 3 shows the mean weight gain (WG), the average daily weight gain (ADWG), the specific growth rate (SGR), the protein efficiency ratio (PER) and the feed conversion ratio (FCR) of the experimental fish. The initial mean weight of fish was 6.85g while the final mean weight was 27.70g. There was a general increase in weight gain from the first week to the last week of the experiment.

The highest weight gain (25.25±1.75) was achieved with the fish fed with diet D5 containing 80% inclusion level of FWW followed by the fish fed with diet D4 (24.63±0.23) with 60% inclusion level and the least weight gain (16.20±3.47) was recorded with the fish fed with diet CTR containing 0% inclusion level of FWW.

The highest ADWG (0.36±0.03) was achieved by the fish fed with diet D5 followed by that of fish fed diet D4 (0.35±0.00) and the least was recorded by the fish fed diet CRT (0.23±0.06). The values for SGR followed the same trend with highest value recorded in fish fed diet D5 (2.20±0.08) followed by fish fed diet D4 (2.18±0.014) and the least was achieved by the fish fed diet CTR (1.73±0.21). There was no significant difference ($p > 0.05$) between the values recorded for diets D5, D4 and D2 but D5 and D4 differed significantly ($p < 0.05$) from the other diets.

Table 3. Performance Evaluation of *Clarias gariepinus* fed with fermented wheat waste

Parameters	CTR(DietD1)	Diet D2	Diet D3	Diet D4	Diet D5
Initial weight	6.84 ± 0.014^a	6.84 ± 0.014^a	6.85 ± 0.021^a	6.85 ± 0.00^a	6.85 ± 0.014^a
Final weight	23.04 ± 3.48^b	28.05 ± 2.76^{ab}	23.81 ± 3.17^b	31.48 ± 0.23^a	32.10 ± 1.73^a
Weight gain	16.20 ± 3.47^b	21.21 ± 2.77^{ab}	16.96 ± 3.20^b	24.63 ± 0.23^a	25.25 ± 1.75^a
Average daily weight gain	0.23 ± 0.06^b	0.31 ± 0.03^{ab}	0.24 ± 0.04^b	0.35 ± 0.00^a	0.36 ± 0.03^a
Specific growth rate	1.73 ± 0.21^b	2.01 ± 0.14^{ab}	1.77 ± 0.19^b	2.18 ± 0.014^a	2.20 ± 0.08^a
Survival (%)	90 %	95%	85%	100%	95%
Protein efficiency ratio	0.41 ± 0.09^b	0.53 ± 0.07^{ab}	0.43 ± 0.08^b	0.62 ± 0.01^a	0.63 ± 0.04^a
Feed conversion ratio	1.26 ± 0.29^a	0.95 ± 0.13^{ab}	1.20 ± 0.23^{ab}	0.81 ± 0.01^{ab}	0.80 ± 0.05^b

Mean and SD within the same row and followed by the same superscripts are not significantly different ($p > 0.05$).

Water Quality Parameters

Table 4 shows the result of water parameters recorded during the period of the experiment. The temperature values ranged between 25.39-25.87℃, while the dissolved oxygen values ranged between 5.22-5.33 mg/L. pH values ranged between 6.84-6.93.

Table 4. Mean Water Quality Parameters Recorded During the Experimental Period

Tank	Temperature (℃)	DO (mg/Litre)	pH
CTR	25.73 ± 0.71^{a}	5.26 ± 0.014^{b}	6.86 ± 0.03^{ab}
D2	25.81 ± 0.74^{a}	5.22 ± 0.035^{b}	6.93 ± 0.00^{a}
D3	25.79 ± 0.79^{a}	5.27 ± 0.007^{b}	6.91 ± 0.04^{ab}
D4	25.87 ± 0.59^{a}	5.22 ± 0.007^{b}	6.89 ± 0.02^{ab}
D5	25.39 ± 0.22^{a}	5.33 ± 0.014^{a}	6.84 ± 0.00^{b}

Mean and SD within the same column and followed by the same superscripts are not significantly different ($p > 0.05$).

Proximate Composition of the Experimental Fish

The carcass composition of the experimental fish is given in Table 5. Fish fed with diet D5 had the highest crude protein value while fish fed with diet D2 had the least crude protein value among the final body composition samples. Crude protein level of all the fish fed with the experimental diets increased compared to the initial protein level. Lipid for fish fed with diet D2 had the highest value among the final body compositions while fish fed with diet D4 had the least lipid value. Ash content among the final carcass compositions was highest in fish fed with diet D2 and the lowest was found in fish fed with diet CTR. There was no significant difference ($p > 0.05$) in the protein values for diet D4 and diet D5. Also there was no significant difference ($p > 0.05$) between the protein values of CTR, D2 and D3 but CTR and D3 differed significantly ($p < 0.05$) from that of the initial.

Table 5. Carcass Composition of Experimental Fish

	Initial	Diet CTR	Diet D2	Diet D3	Diet D4	Diet D5
Protein	47.75 ± 0.28^{c}	55.21 ± 1.11^{b}	52.29 ± 2.18^{bc}	55.29 ± 3.47^{b}	60.37 ± 1.23^{a}	60.75 ± 1.76^{a}
Ash	12.85 ± 0.38^{a}	10.14 ± 1.48^{a}	13.61 ± 0.21^{a}	13.59 ± 0.54^{a}	12.80 ± 1.78^{a}	10.19 ± 2.22^{a}
Lipid	24.84 ± 0.36^{a}	20.94 ± 0.69^{bc}	22.07 ± 2.12^{ab}	18.88 ± 1.89^{bc}	17.18 ± 1.40^{c}	18.74 ± 1.77^{bc}
Moisture	11.39 ± 0.57^{a}	9.47 ± 0.53^{ab}	7.96 ± 0.52^{bc}	8.88 ± 0.94^{bc}	7.05 ± 1.42^{c}	7.45 ± 0.72^{bc}

NFE	3.17±0.28[a]	4.24±0.26[a]	4.07±0.36[a]	3.36±0.09[a]	2.60±2.27[a]	2.87±1.47[a]

Means and SD within the same row and followed by the same superscripts are not significantly different ($p > 0.05$).

Cost of Experimental Diets

Table 6 shows the cost of the experimental diets. The feed with the highest cost per kg is the control (₦315.90), while that with the lowest cost per kg is D5 (₦302.86). The costs of the experimental diets were found to be reducing with increase in the inclusion level of the test ingredient.

Table 6. Cost of Experimental Diets

Ingredients	Diet CTR (₦)	Diet D2 (₦)	Diet D3 (₦)	Diet D4 (₦)	Diet D5 (₦)
Fishmeal (72%)	177.86	176.51	175.34	173.99	172.93
Soybean meal (45%)	50.50	50.86	51.20	51.60	51.96
Maize meal (10%)	17.66	14.13	10.60	7.07	3.53
FWW (11.03%)	_	1.14	2.28	3.42	4.56
Methionine	4.0	4.0	4.0	4.0	4.0
Vitamins/Mineral Premix	40.0	40.0	40.0	40.0	40.0
Starch	0.88	0.88	0.88	0.88	0.88
Vegetable oil	25.0	25.0	25.0	25.0	25.0
Cost/kg feed	315.9	312.52	309.3	305.96	302.86

DISCUSSION

Feeding of fish during culture aims at producing the maximum weight of marketable fish within the shortest time at least cost. The feed should supply the energy for movement and all other activities the fish engages in. It should also provide nutrients for body maintenance, growth and reproduction (MOFA, 2017). The use of by-products of feedstuff in livestock feeding is not new, Ellis and Bird (1951) reported that by-products make up about one third of the poultry ration and about one-seventh of the ration for growing and fattening swine in the United States, and has served greatly in reducing cost of production and for the sustainability of the livestock industry. Also Tacon (2015) reported on several authors who have worked on supplementation of expensive feed ingredients with less expensive ones.

The proximate composition of fermented wheat waste (11.03%) is in the range reported for whole wheat grain (8-15%) by Shewry (2009), it was observed by Ellis and Bird (1951) that most byproducts of wheat exceeded whole wheat in protein, thiamine, riboflavin, niacin, and vitamin E. Fermentation also has been observed to improve the protein content of feedstuffs (Balagopalan *et al*., 1991).

The physico –chemical parameters of water used for fish culture during the experimental period were within the range recommended for African catfish culture (Boyd, 1979).

All the experimental diets were accepted by the experimental fish indicating that the incorporation of Fermented Wheat Waste (FWW) in fish diet did not have adverse effect on the palatability of the experimental diet. This might be attributed to the processing technique which the wheat seed had been subjected to prior to pap production. This finding agrees with

Walker (1980) who reported that processing increased the feeding value of feeds by increasing digestibility, inactivating specific growth inhibitors and increasing the nutritional value of feeds, thereby resulting in better palatability and growth in fish.

The best growth performance and nutrient utilization was recorded in fish fed D5 (80% inclusion level), followed by fish fed D4 (60% inclusion level). All the fish fed the test diets performed better than that fed with the control diet with no FWWM with increase in the inclusion levels of FWWM in fish diet resulting in increased growth performance and nutrient utilization of experimental fish. This is an indication that feeding FWWM to *Clarias gariepinus* fingerlings resulted in better utilization of the diets, had a positive effect on its growth and nutrient utilization and could be included up to 80% inclusion level. This result is similar to what was reported by Aderolu *et al.* (2011), Fakumoju *et al.* (2016) and Obasa *et al.* (2013) who reported best growth performances at 75%, 100% and 50% substitution levels of maize with various lesser - used ingredients in the diets of *C. gariepinus, Tilapia niloticus* and *C. gariepinus* respectively but in contrast to the work of Jimoh *et al.* (2014) who reported progressively poorer growth with increasing substitution levels of *Chrysophylum albidum* seeds meal with maize in the diet of *C. gariepinus.*

The percentage survival was good throughout the experimental period. This could be as a result of good water quality management, good handling and suitability of Fermented Wheat Waste Meal as inclusion in *Clarias gariepinus* diet.

The cost of replacing maize meal with FWWM showed that the cost of producing 1kg of feed reduced as the inclusion level increased. This is an indication that producing feed where the maize is partially substituted for FWWM would be more economical and could bring about more production at lower cost.

CONCLUSION

The high competition for maize due to the fact that it is a major ingredient and source of carbohydrate in human food, animal and fish/shrimp feeds, makes maize to be costly and scarce. This was addressed in the present study in the use of FWWM in fish compounded feed as a replacement for maize. FWWM which is usually discarded after the processing of wheat into pap, has proven to be efficacious in fish feed preparation.

Furthermore, it was fascinating to note from the study that the fish fed with diet containing 80% inclusion level of FWWM performed better in all the parameters measured than fish fed on maize (control) as the main energy source, also the weight gain of fish fed with FWWM at 20%, 40%, 60% and 80% inclusion levels were better than fish fed with maize (control) at 0% inclusion level of FWWM. This study also shows that FWWM is a very good source of energy for *C. gariepinus*, readily available, cheap and easily propagated as against maize which is expensive and scarce. Therefore, the use of FWWM is far more economical than using maize as the main energy source and it is recommended in feeding *C. gariepinus* fingerlings.

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