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Utilization of *Corchorus olitorius* leaf as binder in the diet of *Oreochromis niloticus* fingerlings

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Abstract. *This study was carried out to evaluate the physical properties and dietary value of feeds made using Corchorus olitorius as binders in fish feeds. Six isonitrogenous diets were prepared using maize wheat or maize and wheat as energy source. The diets were designated as MAI, WHC, MAW, MAC, WHC and MWC. With the first three being bounded with corn starch and the last three being bounded with C. olitorius leaves soaked for 24 hours and pelleted. Physical properties evaluated are sinking rate, water absorption index, water stability, bulk density, thickness strength, friability and hardness. There was significant differences (p<0.05) in the water stability, water absorption index and thickness swelling of the diet. The highest water stability value was recorded in diet MAW. For growth parameters and nutrient utilization by fish fed experimental diets, diet MWC had a significantly higher mean final weight (9.42±0.41g), mean weight gain (5.43±0.41g), feed efficiency ratio (0.93±0.13) and specific growth rate (1.22±0.06%d^{-1}). There was no significant difference in the feed conversion ratio, mean feed intake, and survival rate. The result shows that diet bounded with C. olitorius leaf had better utilization compared to corn starch bounded feed.*

Keywords: binders, fish feed, growth, nutrient utilization, physical properties

Abreviations: MAI- maize only, WHE- wheat only, MAW- maize and wheat only, MAC- maize and *C. olitorus*, WHC- wheat and *C. olitorus*, MWC- maize, wheat and *C. olitorus*.

Introduction

Fish reared in an enclosure require adequate nutrients to stay alive, healthy and active. Such nutrients provided in the feed should allow for growth, reproduction and maintenance. Fish nutrition is therefore critical to successful fish rearing. Feed represents 60-80% of the production costs (Orire and Sadiku, 2014). Feed production and quality is considered to be one of the major factors influencing the success of fish production in aquaculture (Udo and Umanah, 2017). There is need for technology that will reduce cost and produce quality fish feed. Quality feed when fed at the recommended rate under optimal water quality conditions lead to profitability. However, bioavailability of the nutrients and the physical quality of the feed, which can be affected by processing technology, are the most important factors in order to maximize feed utilization. Moreover, the feed should ensure good health and high quality on the end product. Whereas nutrient requirement is well established for many aquatic species (NRC, 1993), other quality attributes such as physical quality of feed is less standardized. To achieve the availability of nutrients required by the fish in order to make nutrients available, different feed stuffs are mixed and pelletized. Binders are of great importance in the production of fish feed pellets. Different binder sources from starchy plants to synthetic ones have been used to make fish pellets.

Corchorus olitorius Linn. (Tiliaceae) is an annual herb with slender stems. *C. olitorius* also known as jute plant or bush okra is an important green leafy vegetable in many tropical Africa countries, Japan, South America, the Caribbean and Cyprus (Loumeren and Alercia, 2016). In West African countries particularly Ghana, Nigeria and Sierra Leone, leafy vegetables are used to complement staple, starchy dietary food-stuffs such as rice, cassava, maize and yams (Tulio et al., 2002). The leaves of *C. olitorius* are used in food as a vegetable or used to make a sticky cooked sauce that accompanies the main courses (Abou-Zeid, 2002; Adjatin et al., 2017). *Corchorus olitorius* leaves are very rich in amino acid, potassium, protein and iron. It also contains vitamins A, C, K and B_6 (Palada and Crossman, 1998; Shashi et al., 2013). The objective of this study is to evaluate the use of *C. olitorius* leaf as binder in the diet of *O. niloticus* fingerlings.

Material and methods

Preparation of experimental feeds

Six diets with 35% crude protein (CP) were prepared (Table 1). Feed materials were purchased from a feed mill in

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Akure. The feed ingredients were grinded separately to fine particle. The main ingredients were fish meal, groundnut cake, maize and wheat. Maize and wheat were used separately and in combinations with any of *Corchorus olitorus* leaf powder or corn starch. The inclusion level of the ingredients were calculated using Pearson square method. Vitamin and mineral premix, oil were included at fixed inclusion level. The ingredients were weighed in the right proportion. Dried leaf powder of *C. olitorus* at 5% inclusion level was mixed with 1.5 litre of 100°C water and left for 24 hours. The solutions were poured into the dry mash. Diets containing maize or wheat or both had starch as their binders.

The prepared six diets were mixed thoroughly to get homogenous mixture of the feed. The diets were pelleted after the conditioning. Pelleted feeds were air-dried.

Table 1. Gross composition of experimental diets (g/100g) and proximate composition

Ingredients	MAI	WHE	MAW	MAC	WHC	MWC
Fish meal (65% CP)	15	15	15	15	15	15
Soya bean meal (42% CP)	27	27	27	27	27	27
Groundnut cake (48% CP)	30	30	30	30	30	30
Maize	18	-	9	18	-	9
Wheat	-	18	9	-	18	9
Vegetable oil	3	3	3	3	3	3
Vitamin/Mineral premix	2	2	2	2	2	2
Corn starch	5	5	5	-	-	-
Corchorus olitorius	-	-	-	5	5	5
Total	100	100	100	100	100	100
Proximate composition (Dry matter)						
Moisture	9.81	9.91	9.66	9.72	9.91	9.91
Crude protein	35.06	35.05	35.13	35.48	35.03	35.87
Lipid	14.64	14.61	14.45	14.84	14.98	14.98
Crude fibre	7.87	7.81	8.18	8.04	8.95	8.95
Ash content	9.64	9.83	9.91	9.69	9.46	9.46
NFE	22.98	22.79	22.67	22.23	21.67	21.67

*MAI- Maize only, WHE- Wheat only, MAW- Maize and Wheat only, MAC- Maize and *C. olitorus*, WHC- Wheat and *C.*, MWC- Maize, Wheat and *Corchorus olitorus*, NFE- Nitrogen free extracts

Phase 1: Physical properties of experimental feed

Determination of Water Absorption Index (WAI): The WAI was determined by subtracting the final mass from the initial mass of the pellet. The difference is then divided by the initial mass of the pellet before been immersed in water.

WAI (g) = $(M_2 - M_1)/M_1$,

Where:

M_1 = mass of pellet before immersion in water;

M_2 = mass of pellet after immersion in water.

Determination of Sinking Rate (SR): The Sinking rate was determined by observing the time taken by the pellets to reach the bottom of water column of 30 cm height. Sinking rate was calculated using the formula by Moond et al. (2004);

SR (cm/s) = Length of water column (cm) / Time taken (s)

Determination of Thickness Swelling (TS): The thickness swelling of the pellet was determined using a Vernier calliper before immersion in water (T_1). The thickness swelling were measured after immersion of the pellet in water (T_2) (Adeparusi and Famurewa, 2011). The thickness swelling of the pellet sample were determined by dividing the difference of T_1 and T_2 by T_1, i.e;

Thickness Swelling (mm) = $(T_2 - T_1)/T_1$,

Where:

T_1 = the thickness of the pellet sample before immersion (cm);

T_2 = the thickness of a pellet sample after being immersed in water for three minutes (cm).

Determination of Water Stability (WS): Triplicates samples (10 g each) of each pelleted feed were placed in a nylon sieve tied with rope and slowly immersed in 500 cm^3 of tap water. Aeration was done using a ceiling fan. There was occasional shaking for 10 seconds every 2 minutes. The pellets were allowed in the water medium for a period of 20 minutes. At the end of each test time, the sacks were removed with the aid of the rope. The crumbles were allowed to drain for one minute and the content put in a petri-dish and oven dried at 105°C for 2 hours. It was then cooled in desiccators and weighed. The new weight represented the left over from the original 10 g.

Water stability of the pellet was calculated as the percentage of the weight retained against the initial total sample dry weight using the equation as described by Solomon et al. (2011);

WS (%) = (Weight of retained whole pellets / Initial total weight of pellets).100

Friability Test: 10 g of the pelleted feed were put in a container and adapted to a rotary machine as described by Orire et al. (2010). Centrifuge machine (IEC clinical centrifuge, International Equipment Company, USA) was used at the laboratory of the Department of Fisheries and Aquaculture technology. The dust generated was collected through a sieve and weighed. The weight was expressed as a percentage of the sample.

Friability (%) = (Weight of dust generated / Initial weight of pellets).100

Hardness Test: The hardness test of the experimental feeds was carried out using a Californian Bearing Ration machine (Model no BS1377) at the Department of Applied Geology, Federal University of Technology, Akure (FUTA). The load-measuring device was connected to a compression machine. The mould with the sample and the surcharge weight was placed in the machine. A plunger was seated on top of the specimen and it was done to allow free movement of the plunger from the surcharge weight. The seating load was applied by weight. The displacement-measuring device was adjusted to zero. The motor drive was switched on the loading started with a loading rate of 1 mm/min. The breaking point was noted.

Determination of Nutrient Retention (NR): Total protein, total carbohydrate and total lipid in pelleted feed samples before and after immersion were determined using methods of AOAC (2010). The values of nutrients retention is expressed on percentage remaining basis.

NR (%) = (N_1 / N_2).100,

Where;

N_1 = the initial nutrient composition of the pellet before immersion in water;

N_2 = the final nutrient composition of the pellet after immersion in water.

Experimental fish and feeding trial

Oreochromis niloticus fingerlings (3.98-3.99 g) used for this study were obtained from the hatchery of the Department of Fisheries and Aquaculture Technology, FUTA. The fish were acclimatized to laboratory condition for seven days and fed commercial feed. Healthy fish were randomly distributed into 18 plastic tanks (0.75×0.45×0.30 m = 0.10 m^3) at a stocking density of 10 fish per tank (0.10 m^3). The culture system used was flow-through system.

The feeding trial lasted for 70 days. Fish were hand fed between 08.00-09.00 h and 14.00-15.00 h GMT. Fish were fed diets at the fixed rate of 5% body weight per day. Fish were batch weighed fortnightly to monitor growth and adjust feeding rates accordingly.

Monitoring of water quality parameters

Monitoring of the water culture was carried out daily and the assessed parameters included: Temperature (°C), hydrogen-ion concentration (pH) and dissolved oxygen (DO, mgO_2/l). Dissolved oxygen and temperature were measured using combined digital YSI Do Meter (YSI, Model 57) while pH was monitored using a portable pH-meter. The pH of water used for culture was between 6.64 and 7.46, temperature ranged from 25.43 to 25.61°C and DO was between 5.41 and 6.45mgO_2/l. These ranges were within optimal limits recommended for the fish.

Phase 2: Assessment of growth parameters and nutrient utilization

The following growth and nutrient utilization indices were evaluated as described by Fasakin et al. (2003) and Ridha (2006):

Weight Gain (WG): WG = $W_2 - W_1$, where W_2 is the final weight of fish and W_1 is the initial weight of fish in each tank.

Specific Growth Rate (SGR):

SGR ($\%d^{-1}$) = $[100(\ln W_2 - \ln W_1)] / t$,

Where; W_1 and W_2 are the initial and final fish weight, respectively, and 't' represents the duration of the feeding trial.

Survival Rate (SR): SR (%) = (N_1 / N_0).100,

Where:

N_1 = Total number of fish survival in pond at end of experiments;

N_0 = Total number of fish in tank at the beginning of experiments.

Feed Conversion Ratio (FCR):

FCR = Weight of feed intake (g) / Weight gain by fish (g)

Feed Efficiency Ratio (FER):

FER = [Wet weight gain (g)/ Dry feed intake (g)]

Proximate analysis of experimental fish

Fish were sampled at the beginning and end of the feeding experiment for proximate analysis using the methods described by AOAC (2010).

Statistical analysis

One-Way Analysis of Variance (ANOVA) were used for analysis of data. Tukey's test was used to separate means where significant difference occurs ($p<0.05$) using the Statistical Package for Social Science (SPSS). Three-dimensional surface plots were generated to describe the interaction between parameters and to find optimal values for each parameter.

Results and discussion

The results of physical properties of experimental diets are presented in Table 2. There was no significant difference in the sinking rate and bulk density of the experimental diets. There were significant differences ($p<0.05$) in the water stability, hardness and water absorption index of the diets. The friability test results for experimental diets are presented in Table 3. The results showed that as the speed increased, the dust generated also increased. There was significant difference ($p<0.05$) in the friability of experimental diets. The dust generated ranged between 0.02 to 1.21%. The least friability was recorded in diet MAI (0.61±0.00) and the highest was in diet MAC (1.21±0.00) at 100 rpm.

Table 2. Physical properties of experimental diets with *C. olitorius* leaf as binder

Diets	Sinking rate (cm/s)	Thickness strength (mm)	Bulk density (g/cm^3)x10^{-4}	Water absorption index (g)	Hardness	Water stability (%)
MAI	7.86±0.37[a]	0.08±0.01[cb]	1.00±0.00[a]	1.35±0.01[c]	5.0±0.00[a]	85.20±0.10[a]
WHE	9.35±0.85[a]	0.10±0.00[c]	1.00±0.00[a]	0.93±0.01[a]	7.5±0.71[ab]	88.10±0.12[d]
MAW	11.70±0.65[a]	0.07±0.02[abc]	1.00±0.00[a]	1.15±0.01[b]	12.00±0.00[bc]	88.90±0.46[d]
MAC	7.45±0.88[a]	0.05±0.01[ab]	1.00±0.00[a]	1.63±0.00[d]	5.00±0.00[a]	85.17±0.08[a]
WHC	10.51±0.69[a]	0.05±0.01[ab]	1.00±0.00[a]	1.84±0.01[f]	6.00±1.41[a]	88.87±0.12[c]
MWC	9.16±0.78[a]	0.09±0.03[c]	1.00±0.00[a]	1.80±0.00[e]	7.00±1.41[ab]	88.23±0.08[b]

*MAI- Maize only, WHE- Wheat only, MAW- Maize and Wheat only, MAC- Maize and *C. olitorus*, HC- Wheat and *C. olitorus*, MWC- Maize, Wheat and *C. olitorus*; Means with the same superscript along column are not significantly different (p>0.05)

Table 3. Friability of experimental diets

Diets	35 rpm	50 rpm	70rpm	100 rpm
MAI	0.02±0.01[a]	0.13±0.01[ab]	0.32±0.00[a]	0.61±0.00[a]
WHE	0.02±0.01[a]	0.13±0.01[ab]	0.44±0.00[bc]	0.78±0.00[b]
MAW	0.02±0.00[a]	0.13±0.01[ab]	0.54±0.01[e]	0.78±0.02[b]
MAC	0.11±0.01[b]	0.23±0.01[c]	0.80±0.01[g]	1.21±0.00[d]
WHC	0.03±0.00[a]	0.13±0.00[a]	0.61±0.02[f]	0.92±0.00[c]
MWC	0.04±0.01[a]	0.15±0.00[ab]	0.50±0.00[de]	0.87±0.00[c]

*MAI- Maize only, WHE- Wheat only, MAW- Maize and Wheat only, MAC- Maize and *C. olitorus*, WHC- Wheat and *C. olitorus*, MWC- Maize, Wheat and *C. olitorus*; Means with the same superscript along column are not significantly different (p>0.05)

The physical quality of feeds is of great importance in fish nutrition. Formula variations have effect on the properties of fish feed pellets (Saalah et al., 2010). The binders and the combinations of maize and wheat in the diet did not affect significantly the sinking rates of experimental diets. The period it takes for pellets to get to the bottom is enough time for fish to consume the feed when fed at the appropriate time and condition. Water stability of pellets can be greatly improved through proper selection of feed ingredients, processing techniques and the use of proper processing equipment Lim and Cuzon (1994). For *C. olitorius* leaf bounded diets, WHC was significantly higher in water stability than MWC and MAC. The water stability recorded in this study is higher than the water stability of yam starch bounded diets by Orire et al. (2010). The range of values for the water stability (85.17-88.90%) for the diets showed the quality of diets to stay long in water. The differences in the water stability of diets showed that the inclusion of maize or wheat alongside the binders is of great importance. The results are also similar with the results of Momoh et al. (2016) who experimented on the effects of ingredients substitution on the binding, water stability and floating properties of farm-made feeds. There was no significant difference (p>0.05) in the bulk density of experimental diets. This lack of significant difference in bulk density makes the inclusion of the different binders insignificant. Only the binders were different and they are of negligible weight.

Water absorption index value indicates the portion of starch content of the feed. Chevanan et al. (2007) suggested that any change in water absorption index can be due to structural modifications of the ingredients composition, such as starch gelatinization and protein denaturation. The significant difference in the water absorption index of experimental diets is a results of the binders used. The highest water absorption index was recorded in diet WHC and the lowest was recorded in MWC.

Nutrient retention of experimental diets is presented in Figure 1. Crude protein retention for diets was between 90.07% (MWC) and 95.83% (MAI). Lipid retention ranged from 85.72% in diet MWC to 96.53% in diet MAC. Diet WHC had the highest ash retained (82.80%) and the lowest was recorded in diet MAW (76.90%). The values recorded for the nutrient retention showed the ability of the binders to minimize the leaching of nutrients into the culture medium.

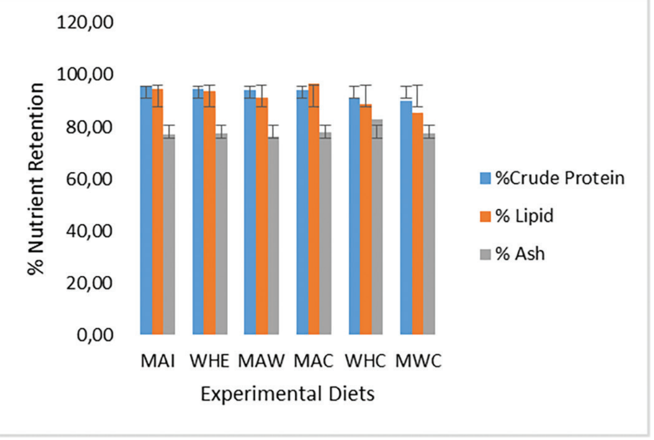

Figure 1. Nutrient retention of experimental diets bounded with *C. olitorius* leaves soaked for 24 hours

There was no significant difference in the FCR, mean feed intake, and survival rate across the treatments (Table 4). There was significant difference (p<0.05) in the mean final weight, mean weight gain, FER, and SGR. Diet MWC had a significantly higher mean final weight (9.42±0.41 g), mean weight gain (5.43±0.41 g), feed efficiency ratio (0.93±0.13) and specific growth rate (1.22±0.06 %d^{-1}) compared to other diets.

Table 4. Growth and nutrient utilization of *O. niloticus* fingerlings fed experimental diets

Parameters	MAI	WHE	MAW	MAC	WHC	MWC
Mean initial weight, g	3.98±0.00	3.98±0.00	3.99±0.00	3.99±0.00	3.98±0.00	3.99±0.00
Mean final weight, g	8.37±0.11[ab]	8.02±0.47[ab]	8.28±1.12[ab]	8.48±0.78[ab]	7.96±0.46[a]	9.42±0.41[b]
Mean weight gain, g	4.38±0.11[ab]	4.03±0.47[ab]	4.29±1.12[ab]	4.48±0.79[ab]	3.97±0.46[a]	5.43±0.41[b]
FCR	1.29±0.31[a]	1.33±0.19[a]	1.31±0.17[a]	1.19±0.25[a]	1.36±0.14[a]	1.07±0.04[a]
FER	0.78±0.37[a]	0.75±0.20[a]	0.77±0.35[a]	0.84±0.39[a]	0.74±0.26[a]	0.93±0.13[b]
SGR	1.05±0.02[ab]	0.99±0.08[ab]	1.03±0.19[ab]	1.07±0.13[ab]	0.98±0.08[a]	1.22±0.06[b]
Mean Feed intake, g	5.65±1.44[a]	5.36±0.34[a]	5.60±0;12[a]	5.33±0.48[a]	5.40±0.23[a]	5.81±0.00[a]
Survival, %	71.1±13.87[a]	71.1±10.18[a]	71.1±26.94[a]	88.9±7.69[a]	91.1±10.18[a]	86.7±11.54[a]

*MAI- Maize only, WHE- Wheat only, MAW- Maize and Wheat only, MAC- Maize and *C. olitorus*, WHC- Wheat and *C. olitorus*, MWC- Maize, Wheat and *C. olitorus*; Means with same superscript across row are not significantly different (p>0.05)

The growth rate of fish fed experimental diets showed that fish fed diets MWC had the highest mean weight gain, and SGR; low FCR and high FER. This is followed by MAC and MAI. This shows that diet bounded with *C. olitorius* leaf had better utilization in combination with equal proportion of maize and wheat in the diet of *O. niloticus*. Fish fed diet MWC had the highest mean weight gain of 5.43±0.41g which was significantly higher than that obtained in other treatments. The use of wheat only with *C. olitorius* leaf as binder (WHC) had the lowest mean weight gain, SGR and FER; high FCR. This shows that *O. niloticus* fingerlings used in this experiment did not utilize diet WHC adequately. The FCR results of this study are lower than those of Singh et al. (2016) in their study on the use of *C. olitorius* leaf as an additive in the diet of *Labeo rohita* fingerlings. They had a FCR value range 2.05 to 4.31 for *Labeo rohita* fingerlings fed *C. olitorius* leaf which was higher than the results in this study.

The initial crude protein of experimental fish was higher than the final crude protein content of the experimental fish with the highest crude protein fed experimental diets (Table 5). The reduction in the crude protein content of whole body carcass of experimental fish might be unavailability of other supplementary feeds apart from the experimental diets. The fish used were cropped from earthen pond where there is availability of natural foods. The crude protein content of fish carcass fed diet MWC was higher than in other treatments. This might be a result of the diet MWC having the highest crude protein contents. Fish fed diet MWC also had the least Ash and fat content. The whole body composition of *O. niloticus* fed *C. olitorius* leaves bounded diets compared favourably with those fed butyric acids in terms of crude protein, fat and ash content in a study by Omosowone et al. (2019).

Table 5. Carcass composition (dry matter basis) of *O. niloticus* fed experimental diets

Diets	Moisture	Crude Protein	Fat	Ash	NFE
Initial	7.14±0.37	51.27±0.23	11.54±1.46	14.93±1.78	15.12±0.24
MAI	2.92±1.31[a]	49.14±0.28[abcd]	17.32±1.37[ab]	19.21±1.46[ab]	11.41±0.93[a]
WHE	2.90±0.06[a]	47.15±0.24[ab]	19.49±0.73[b]	19.89±0.02[b]	10.59±0.57[a]
MAW	2.22±0.34[a]	48.38±0.23[abc]	17.93±0.57[ab]	17.67±0.94[ab]	13.81±1.62[a]
MAC	3.15±0.81[a]	50.00±0.18[cd]	19.92±1.60[b]	15.92±1.23[a]	11.02±1.36[a]
WHC	2.58±0.11[a]	47.01±0.33[a]	17.96±0.40[ab]	17.96±1.02[ab]	14.49±1.06[a]
MWC	2.71±0.33[a]	51.05±1.19[d]	14.41±0.52[a]	15.41±1.94[a]	16.44±3.32[a]

*MAI- Maize only, WHE- Wheat only, MAW- Maize and Wheat only, MAC- Maize and *C. olitorus*, WHC- Wheat and *C. olitorus*, MWC- Maize, Wheat and *C. olitorus*, NFE- Nitrogen Free Extracts; Means with different superscript along columns are significantly different (p<0.05)

Conclusion

The results of the physical properties of diets bounded with *C. olitorius* leaf show that the leaves can be used as binders in fish when compared with Corn starch. This is in addition to the effects it has on the nutritional content of diets as shown in the weight gain of fish fed diets containing the leaf. Also, the growth parameters and nutrient utilization by experimental fish in this study shows that *C. olitorius* leaf can be included in the diet of *O. niloticus*.

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