Effects of water hyacinth leaf meal feed on growth and body composition of African catfish, *Heterobranchus longifilis*, (Valenciennes, 1840)

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Abstract:

A 8-week feeding trial was carried out to determine the effect of increasing dietary hyacinth leaf meal levels on African catfish juvenile growth and nutrient utilization. Four is nitrogenous diets were formulated to contain 10% to 40% hyacinth leaf meal. Growth performance, feed and nutrient utilization efficiency and body composition parameters of Heterobranchus longifilis fed diet containing water hyacinth were low than those recorded for Control diet. Growth performance and nutrient utilization efficiency of African catfish responded in a positive manner to hyacinth leaf meal added up to 30%. No further improvement in growth was observed with 40% of hyacinth leaf meal in the diet. Contrary to whole-body protein and energy content there was a significant difference (P<0.05) for ash, moisture and lipid contents. The best growth rate and nutrient utilization were observed with the inclusion of 30% hyacinth leaf meal in the diets for African catfish.

Keywords— Water hyacinth leaf meal, growth, body composition, *Heterobranchus longifilis*, fingerlings

1. Introduction

Aquaculture requires optimization of fish feeding for the purpose of sustainable food production. Fish meal (FM) is known to contain essential amino acids that are needed to meet the protein requirements fish species (Abowei and Ekubo, 2011). The high cost of fish meal and competition with other livestock feed have prompted the search for alternative protein sources (Gan, et al. 2017).

The search for alternatives to fishmeal (FM) has largely focused on conventional sources such oleagineous raw material cakes because of their higher protein content. Despite their usefulness, these ingredients are scarce and expensive because of the high demand for animal production and human consumption (Gabriel et al. 2007). In addition, their cultivation generally requires significant use of inputs and energy subsidies (Francis et al. 2002). This makes them unaffordable, unsustainable for achieving food security particularly among poor farmers. In order to achieve more sustainable fish production, research has been redirected towards the evaluation and use of nonconventional protein sources, particularly from plant products (Ogunji, 2004; Bake et al. 2013).

The use of nonconventional feed stuffs of plant origin has been reported with good growth and better cost benefit values (Sogbesan, 2006). Nowadays, partial or total replacement of protein source in fish meal with plant products has been an area of focus in aquaculture nutrition research.

Water hyacinth (*Eichhorniacrassipes*) is considered as one of the worst aquatic plant and it remains the largest aquatic weed in the world. It forms dense carpets that block navigation and hinder irrigation, fishing, recreation and energy production. These mats also prevent the penetration of sunlight and aeration of water, resulting in oxygen deficiency and reduce biological diversity (N'daandArfi, 1996). Despite its low protein content, water hyacinth contains 30 to 60% nitrogen-free extract (NFE) and 20 to 30% crude fiber.

Water hyacinth is a potential low cost ingredient in on-farm mixed feeds for herbivorous or omnivorous freshwater fish in livestock systems. Previous research has been devoted to the use of water hyacinth in the diet of fish (Hassan et al. 2007).

Some studies have suggested substitution rates of 25 to 50% water hyacinth as a supplement for animal feed or 5 to 10% of protein replacement in formulated feeds (Hertrampf and Piiedad-Pascal, 2000). The nutritional value of water hyacinth and its utility as a weed for animal feed has been reported (Saha and Ray, 2011). However, in Côte d'Ivoire, information on the use of aquatic weeds as fish meal is scanty.

The aim of this study is to investigate the effect of substitution of fish meal with water hyacinth on the growth performance and chemical body composition of African cat fish (*Heterobranchus longifilis*).

2. Material and Methods

2.1. Fish and rearing conditions

Heterobranchus longifilis fingerlings with an average weight of 0.26 ± 0.07g were obtained from the fish hatchery of the Oceanological Research Center in Abidjan (Côte d'Ivoire). The fish were acclimatized to experimental conditions for a period of 2 weeks before starting the experiment. During experiment period they were fed a control diet (CD) with 35% protein. A total of 750 fish were randomly divided into five different groups with three replicates containing 50 fish in each replicate based on completely randomized design. Prior to the treatments, 50 fish were frozen (–20◦C) for proximate analysis. The fish were kept in 50-L glass tanks containing 45 L of well aerated water, with 30% of this water daily replaced. The water quality was daily evaluated at 08:00 by measuring temperature, dissolved oxygen (CRISON Oxi 330, WTW GmbH, Weilheim, Germany), and pH (pH 90, WTW GmbH, Weilheim, Germany). Throughout the experimental period the water temperature, pH, and dissolved oxygen varied between 28.8 and 29.6◦C, 6.6–7.3, and 7.7–8.3 mgL−1, respectively, and were considered favorable for fish culture (Boyd, 1990).

2.2. Experimental diets and methods

Four is nitrogenous experimental diets (10%, 20%, 30%, 40%) and Control Diet (CD) were used. The four test diets had *Eichhorniacrassipes* leaf powder incorporation at levels of 100, 200, 300 and 400 g/kg respectively. The formulation and proximate composition of the diets are presented in Table 1. Each diet was distributed to apparent satiation twice daily for a period of 56 days. Daily feed intake was recorded, and to quantify the exact amount of feed ingested, any feed refused was siphoned out, dried and weighed.

Fish body weight from each tank was recorded weekly, and tanks were cleaned. Deaths were removed every day. At the end of the experiment, fish were weighed individually. All fish were killed and samples from a single tank were immediately frozen at -20°C for further determination of whole body composition.
All the fish from the same tank were then frozen (–20◦C) for further determination of whole-body composition.

Proximate composition of diets and fish were analyzed using the following procedures: dry matter after drying at 105◦C for 24 h, fat by petroleum ether extraction (Soxtherm, Gerhardt, Germany), protein content (N × 6.25) by the Kjeldahl method after acid digestion, ash by combustion at 550◦C in a muffle furnace to a constant weight; crude fibre by acid/alkali digestion. The gross energy (GE) contents of the fish and diets were calculated from the fat and protein contents using the equivalents of 38.9 KJ.g−1 crude fats, 22.2 KJ.g−1 crude protein, 17.2 KJ.g−1 and carbohydrate (NFE)

Daily weight gain (DWG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), Daily feed intake (DFI), protein gain (PG), lipid gain (LG) and nitrogen loss (NL) were calculated using the following formulas :

-Daily weight gain (DWG) = (W2 –W 1)/t; W1 is the mean initial and W2 mean finalfish weight.
- Specific growth ratio (SGR) = 100 (LnW2 - LnW1) / t; where W1 is the Initial body weight,W2, the Final body weight and t the duration of the experiment.
-Feed conversion ratio (FCR) = Dry feed consumed (g dry weight)/weight gain (g).
-Protein efficiency ratio (PER) = weight gain (g)/protein consumed (g).
-Daily feed intake (DFI) = (daily feed consumed (g)/average total weight (g)) ×100.
-Protein gain (PG) = P2 –P 1 and Lipid gain (LG) = P2 –P 1; P 1 is the protein or lipid in fish carcass (g) at the beginning of the study and P2 is the protein or lipid in fish carcass (g) at the end of the study.
-Nitrogen loss (NL) = Nitrogen intake - Nitrogen gain
-Gross energy = 22.2 × protein content + 38.9 × lipid content + 17.2 × carbohydrate content (kJ)

All data were subjected to analysis of variance (ANOVA) using Statistica, statistical software for Windows (release 7.1), and comparisons among treatment means were carried out by Duncan's test ($p < 0.05$) [13].

3. Results

Growth performance of *Heterobranchus longifilis* fingerlings fed with the five experimental diets are shown in Table 2. Growth performance was improved when dietary *Eichhorniacrassipes* meal level increased from 10% to 30% and then decreased with the diet containing 40% *Eichhorniacrassipes* meal. At the end of the experimental period (56 days) the group of fish fed 30% *Eichhorniacrassipes* meal had a higher daily body weight gain, specific growth rate and lower feed intake than the other experimental groups. The lowest performance was observed in the group of fish fed 40% *Eichhorniacrassipes* meal. Survival rate of fish fed 20, 30, 40% of *Eichhorniacrassipes* meal were higher than those of fish fed 10% and CD, but this parameter did not differ between the different groups.

FCR and PER of the group fed 30% *Eichhorniacrassipes* level were better than fish fed CD, 10%, 20%, or 40%*Eichhorniacrassipes* (Table 3). Protein gain was higher ($P < 0.05$) with diet containing 20%, while the highest lipid gain was recorded for fish fed 30% with the lowest loss nitrogen.

Data on body proximate composition after the56-day feeding trial are presented in Table 4. Values of all parameters(moisture, crude protein, crude lipids, crude ash, and energy) wereall significantly different among treatments. Moisture content of fish fed with 20, 30, 40% *Eichhorniacrassipes* diet was significantly higher than other fish groups. Fish fed with experimental diets presented high lipid content at 30% *Eichhorniacrassipes* and low crude protein.

4. Discussion

The present study demonstrated that experimental diets incorporating water hyacinth favor the growth of juvenile *Heterobranchus longifilis*. The incorporation rate up to 40% *Eichhorniacrassipes* leaf meal in formulated feeds did not have negative effect on survival and growth parameters. The high survival rate recorded during this study is due to the maintenance of hydrochemical parameters in the required for the catfish species, as well as to the application of optimized technological parameters - loading density, diet daily feed, feeding frequency.

In this study, growth performance, feed and nutrient utilization efficiency and body composition parameters of *Heterobranchus longifilis* fed diet containing water hyacinth were low than those recorded in fish fed diet without water hyacinth (Control diet). This reduction could be attributed, not only to dietary amino acid profile of the ingredient, but also to the presence of anti-nutritional factors in *Eichhorniacrassipes*. This assertion is in agreement with the findings of some authors (Jimoh and Aroyehun, 2011; Bake et al. 2015) that higher inclusion levels of most plant protein source meals resulted in poor growth and nutrient utilization. Thus, improved growth performance ranging from 10 to 30% incorporation of *Eichhorniacrassipes* meal for 56 days indicates the ability of juveniles of African catfish to utilize the nutrients of hyacinth meal for growth. These results indicate that *Heterobranchus longifilis* juveniles have successfully used nutrients from the hyacinth meal. These results are in agreement with those obtained by some authors (Sivani et al. 2013; Staykov et al. 2015; Nyadjeu et al. 2018) who found that the partial substitution of plant sources in fish diets improved growth performance of fish.

Indeed, growth increased with increase in *Eichhorniacrassipes* leaf meal up to 30% incorporation. Only optimum level of 30% incorporation yielded better results in terms of growth. It was further observed that better growth may be partly due to fiber content of *Eichhorniacrassipes*, as the optimum level of crude fiber is beneficial in improving the utilization of some nutrients (Steffens, 1981). Some studies also reported that for lower level of incorporation, a physiological mechanism exists in fish that could balance and compensate for the presence of the antinutrients (Bake et al. 2013; Francis et al. 2001). However, at higher levels of substitution (more than 40% of water hyacinth) the negative effects of anti-nutrients would be observed. Thereby the growth performance and feed utilization efficiency decreased thereafter with increase in *Eichhorniacrassipes* leaf meal incorporation to 40%. This could be attributed to the reduced digestibility due to higher carbohydrate content. It has been reported that reduced digestibility with increased carbohydrate content is related to actual reduction in gland stimulation, and enzyme reduction.

Moreveritis known that the presence of anti-nutritional factors in nonconventional foodstuffs of plant origin at higher inclusion levels is known to have negative impact on growth and other physiological activities (Oresegun and Alegbebele, 2001; Ferouz and Kassiviswanathan, 2012). Today, it is possible to improve nutrient digestibility and utilization of these plants based protein sources by reducing their anti-nutritional factors. Different processing techniques including fermentation techniques are often used. Fermentation has long been used to prepare healthy foods for humans and livestock. Fermentation is a unique process which could improve the nutritional value of feed ingredients and tremendously reduce the anti-nutritional factors and fibre content in the plant based feed ingredients. Some authors reported that the growth performance and body composition of fish were better when fish fed containing fermented plant based ingredients (Bake et al. 2015; Jafer et al. 2018].

5. Conclusion

Acceptable growth and meat quality was recorded in African catfish fed with 30% water hyacinth for 56 days. It also suggested that fermented water hyacinth could have a better impact on the growth and body composition of fish at high levels (> 30%). In developing countries like Côte d'Ivoire, water hyacinth is could be an abundant alternative ingredient for fish meal formulation.

6. References

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Table 1 :**Composition of feed ingredients in different feeds and proximate composition of test diets**

Ingredients (g/100g)	DC	Experimentaldiets			
		10%	20%	30%	40%
Fish meal	35.60	32.04	28.48	24.92	21.36
Soybeanmeal	34.00	38.00	39.00	45.00	47.00
Wheat bran	11.00	10.00	10.00	5.00	4.00
Maizemeal	8.00	5.00	4.00	3.00	2.00
*Eichhorniacrassipes*meal	0.00	3.56	7.12	10.68	14.24
Palm oil	8.40	8.40	8.40	8.40	8.40
Vitamin mixture[1]	1.50	1.50	1.50	1.50	1.50
Mineral mixture[2]	1.50	1.50	1.50	1.50	1.50
Total	100.00	100.00	100.00	100.00	100.00
Proximal analysis					
CrudeProtein (%DM)	40.47	40.19	39.12	39.29	38.40
Total fat (%DM)	13.82	13.53	13.23	12.96	12.68
Ash (%DM)	10.04	9.48	8.92	8.32	7.69
Crudefiber (%DM)	3.15	3.46	3.92	4.06	3.24
Nitrogen free extract (NFE) (% DM)	30.07	31.18	32.91	33.80	35.50
Total carbohydrate	33.23	34.64	36.83	37.85	38.75
Digestible energy (Kj/100g)	16.42	16.41	16.29	16.36	16.29
P/E (mg protein / Kj ED)	24.65	24.57	24.01	24.02	23.58

[1]Composition for 1 kg of premix: Vitamin A 1,760,000 IU; Vitamin D3 880,000 IU; Vitamin E (dl-alphatocopherylacetate) 22,000 mg; Vitamin B1 4,400 mg; Vitamin B2 5,280 mg; Vitamin B6 4,400 mg; Vitamin B1 236 mg; Vitamin C 151,000 mg; Vitamin K 4,400 mg; Vitamin B3 35,200 mg; folicacid 880 mg; choline chloride 220,000 mg; Pantothenicacid D-14, 80 mg.

[2]Composition for 1 kg of premix: cobalt 20 mg; iron 17,600 mg; iodine 2,000 mg; copper 1,600 mg; zinc 60,000 mg; manganese 10,000 mg; selenium 40 mg. Nitrogen-free extract (NFE) = 100 – (% protein+% lipid + % moisture + % ash+ % fiber).

Digestible energy (ED) = 18.8 × protein content + 37.7 × lipid content + 11.3 × carbohydrate content. DM: Dry matter; P/E: protein/energy ratio; DC: diet control.

Table 2 : Growth parameters of *Heterobranchus longifilis* fed with different levels of *Eichhorniacrassipes* meal for 56 days

Parameters	DC	Experimental diets			
		10%	20%	30%	40%
Initial body weight (g)	0.26 ± 0.07^{a}	0.26 ± 0.07^{a}	0.26 ± 0.07^{a}	0.26 ± 0.07^{a}	0.26 ± 0.07^{a}
Final body weight (g)	3.94 ± 0.46^{c}	2.92 ± 0.44^{b}	2.97 ± 0.35^{b}	3.54 ± 0.24^{bc}	2.26 ± 0.25^{a}
Daily weight gain (g d^{-1})	0.07 ± 0.01^{c}	0.05 ± 0.01^{b}	0.05± 0.01^{b}	0.06± 0.00^{bc}	0.04± 0.00^{a}
Specificgrowth rate (% d^{-1})	4.86 ± 0.21^{c}	4.33 ± 0.27^{b}	4.36± 0.21^{b}	4.68 ± 0.12^{bc}	3.87 ± 0.20^{a}
Daily feed intake (g $fish^{-1}day^{-1}$)	0.18 ± 0.02^{c}	0.14 ± 0.02^{ab}	0.13 ± 0.00^{ab}	0.16 ± 0.02^{bc}	0.11± 0.02^{a}
Survival	72.00 ± 4.00^{a}	72.67 ± 6.43^{a}	80.00 ± 6.00^{a}	76.00 ± 2.00^{a}	75.33 ± 1.15^{a}

Values are means ± SD (*n* = 3). Means in the same row having different superscripts are significantly different ($P < 0.05$) and values in the same row with same superscript are not significantly different ($P > 0.05$). The values in parentheses represent the standard deviation.

Table 3: Feed and nutrient utilization efficiency of *Heterobranchus longifilis* fed with differents levels of *Eichhorniacrassipes* meal for 56 days

Parameters	DC	Experimentaldiets			
		10%	20%	30%	40%
FCR	2.48 ± 0.05^{a}	2.57 ± 0.04^{a}	2.61 ± 0.21^{a}	2.43 ± 0.23^{a}	2.74 ± 0.20^{a}
PER	1.00 ± 0.02^{a}	0.97 ± 0.08^{a}	1.00± 0.08^{a}	1.07± 0.10^{a}	0.98± 0.07^{a}
PG (g $kg^{-1}day^{-1}$)	3.27 ± 0.15^{b}	2.92 ± 0.41^{ab}	3.04 ± 0.15^{ab}	2.96 ± 0.14^{ab}	2.67 ± 0.10^{a}
GL (g $kg^{-1}day^{-1}$)	0.68 ± 0.03^{c}	0.48 ± 0.08^{b}	0.44 ± 0.03^{ab}	0.63 ± 0.03^{bc}	0.37 ± 0.01^{a}
NL (g $kg^{-1}day^{-1}$)	1.02 ± 0.07^{a}	1.27 ± 0.13^{bc}	1.20 ± 0.15^{ab}	0.99 ± 0.07^{a}	1.44 ± 0.11^{c}

Values are means ± SD (*n* = 3). Means in the same row having different superscripts are significantly different ($P < 0.05$), and values in the same row with same superscript are not significantly different ($P > 0.05$). FCR: Feed conversion ratio; PER: protein efficiency ratio; PG: protein gain; LG: lipid gain; NL: nitrogen losses. The values in parentheses represent the standard deviation.

Table 4:Body composition of *Heterobranchus longifilis*fed with different levels of *Eichhorniacrassipes* meal (on % fresh basis)[1]

Parameters	DC	Experimentaldiets			
		10%	20%	30%	40%
Moisture (%)	79.16 ± 0.66^{a}	79.62 ± 0.85^{ab}	81.09 ± 0.83^{c}	80.21± 0.70^{abc}	80.76 ± 0.42^{bc}
Crudeprotein (%FM)	12.16 ± 0.43^{b}	11.78 ± 0.45^{ab}	11.39 ± 0.55^{ab}	11.11 ± 0.36^{a}	11.57 ± 0.29^{ab}
Total fat (%FM)	2.58 ± 0.10^{d}	2.06 ± 0.07^{b}	1.79 ± 0.11^{a}	2.40 ± 0.06^{c}	1.82 ± 0.03^{a}
Ash (%FM)	2.24 ± 0.15^{b}	2.18 ± 0.16^{b}	1.88 ± 0.16^{ab}	2.01 ± 0.09^{ab}	2.07 ± 0.17^{a}
Cross Energy (kJg^{-1})	3.70 ± 0.13^{b}	3.41 ± 0.12^{a}	3.23 ± 0.16^{a}	3.40 ± 0.10^{a}	3.27 ± 0.07^{a}

[1]Composition of fish slaughtered at the beginning of the experiment (moisture 82.75%; crude protein 11.75%; fat 2.99%; ash 1.61%; gross energy 3.77 KJ.g-1).

Values are means ± SD (*n* = 3). Means in the same row having different superscripts are significantly different ($P < 0.05$) and values in the same row with same superscript are not significantly different ($P > 0.05$). The values in parentheses represent the standard deviation.