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Nutritive value and utilization of water hyacinth (*Eichhornia crassipes*) meal as plant protein supplement in the diet of *Clarias gariepinus* (Burchell, 1822) (Pisces: Clariidae) fingerlings

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ABSTRACT: 120 fingerlings of *Clarias gariepinus* were fed five different experimental 35% isoproteic diets, a control (0% water hyacinth) and four diets containing different levels of water hyacinth (10%, 20%, 30% and 40%) in place of fish meal as protein source at %% of the body weight for 70 days under laboratory condition.

The study revealed a decrease in the growth performance indices as the level of water hyacinth increases. The highest weight gain (3.67g/fish) and specific growth rate (0.84%) and lowest weight gain (3.08g/fish) and specific growth rate (0.54) were recorded from fish fed the control diet and 40% water hyacinth inclusion respectively. There was no significant difference ($P \leq 0.05$) between the weights gains recorded for the fish fed all the experimental diets. The cost of feeds production decreases as the inclusion levels of water hyacinth increases. Highest Net Profit of N224.07 was recorded from fish fed 30% water hyacinth supplemented diet. Based on the result of this experiment, the 40% inclusion levels of water hyacinth as fish meal supplements is recommended in a practical diet of *C. gariepinus* for good yield and profitability.

Key Words: Water hyacinth; Fish meal; Growth performance; Cost benefits; *Clarias gariepinus.*

Introduction

The undersupply and high cost of conventional pelleted fish feed has severely constrained the development of low-cost aquaculture system suitable for small-scale farmers in the developing world (Kusemiju and Akingboju, 1988; Fagbenro and Arowosegbe, 1991) hence the need to assess the potential of non-conventional fish feed ingredients such as water hyacinth – *Eichhornia crassipes* (Mart).

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Edwards (1980) pointed out that compost was considered to have a potential as organic fertilizer in fish culture. Since water hyacinth occurs in many tropical and sub-tropical countries and produces dense mono-specific strands, which often cover hundreds of hectares (Kusemiju and Akingboju, 1988), its utilization could be developed as an important resource for man.

Water hyacinth entered Nigeria waters through pot-novo creek in Benin Republic in September 1984 according to Kusemiju (1988) and since then it has been spreading. This aquatic plant is problematic in Nigeria coastal waters. It blocks the navigation way and greatly reduces the fishing activities, recreational activities within the environment. Edward *et al*., (1985) and Igbinosun *et al*., (1988) have reported on the nutritive value of water hyacinth and its usefulness as animal feed weed. According to Rumsey (1993) increased us of plant protein feedstuffs in fish diets will reduce feed cost and assist in reducing dependence on fish meal as fish protein feedstuff source.

Clarias gariepinus, a mud catfish belongs to the family Clariidae. This specie has maintain its aquaculture quality because of its high growth rate, large size, good flesh quality, tolerance to poor water quality even at larvae state, acceptance of cheap feeds and ability to withstand high stocking densities, disease resistance and good taste (Hongendoorn, 1981, Fang *et al*., 1986; Ayinla, 1988). This study is aimed at determining the best replacement level of fish meal with water hyacinth meal that will favour the growth of *C. gariepinus* and economical viable to the fish farmers.

Materials and Methods

Experimental Set-Up

A total of twelve experimental plastic tanks of 40 litres capacity were used for the trials, carried out in the Hydrobiology and Fisheries Postgraduate Laboratory of the Department of Zoology, University of Ibadan. The tanks were cleaned, disinfected and allowed to dry for 24 hours; after which they were filled with dechlorinated water to two-third of the size of the tanks and were covered with a net of mesh size 3mm to protect the fish from predators. Two tanks were used for each experimental diet.

Experimental Fish

A total number of 250 fingerlings of *C. gariepinus* of weight range 1.20-1.30g (mean weights/SEM of 1.26±0.023g) and Standard length range of 4.30-4.80cm (mean standard length of 4.65/SEM ±0.035cm) were purchased from Oyo State Fish Farm, Agodi. They were acclimatized for one week in plastic holding tanks of 2.0m x 0.5m x 0.4m, aerated and fed the control diet.

Prior to stocking, the fingerlings were starved overnight, then randomly sorted, weighted and stocked into the experimental tanks at the rate of twenty fingerlings per tank. The fingerlings were fed twice daily (between 8.00-8.30hr and 18.00-18.30hr) at 5% body weight for 70 days. Each experiment was duplicated. The quantity of feed was adjusted based on the new weekly weight of fish. Sampling of fish was done weekly for change in the body weight. The tanks were monitored for fish mortality daily. Dead fish were removed, counted and recorded for determination of survival rate.

Experimental Diets

Six experimental diets were formulated based on protein content of the major ingredients. The water hyacinth used was harvested from Awba Reservoir, University of Ibadan, Ibadan. The leaves were sun-dried by spreading the wet leaves on mats and left to dry in the sun for three days (Igbinosun *et al*., 1988). Fishmeal, vitamin and mineral premix, maize was purchased from AGROVIT, Ibadan, while Palm oil and Starch were brought from Bodija market. The feeds were formulated using Pearson's square method. The diets were prepared using water hyacinth meal to replace fishmeal as plant protein source at various inclusion levels of 0%, 10%, 20%, 30% and 40%. These diets were coded WH1 (control diet) to WH5. All feeds were isonitrogenous at 35% crude protein and with caloric content varying within 425.0-400.0 kcal/100g respectively as shown on Table 1. After formulation, the ingredients were measured using electric sensitive weighing balance (OHAUS- LS 2000 model), milled into particulate, which is a common, practiced for fish feed preparation (Falayi, 2003). A combined grinder and mixer (ASEFAC-Model) were used for milling. The ingredients were thoroughly mixed and pelleted wet using kitchen hand crancker pelletizer. The pelleted dough were collected in flat trays and sun-dried to constant weight after which the feeds were crushed into crumbs with pestle and mortar (for easy ingestion by the fingerlings); then stored in jute bags at room temperature.

Table 1: Feed Formulation and Production Costs of the Experimental Diets.

Diets	**WH1**	**WH2**	**WH3**	**WH4**	**WH5**
Inclusion levels of water hyacinth meal	**0% (Control)**	**10%**	**20%**	**30%**	**40%**
Fish meal	44.28	43.99	43.65	43.19	42.61
Water hyacinth meal	-	4.89	10.91	18.51	28.41
Corn meal	45.72	41.12	35.44	28.30	18.98
Palm oil	1.5	1.5	1.5	1.5	1.5
Vitamin and Mineral Premix*	2.5	2.5	2.5	2.5	2.5
Starch (Binder)	3.0	3.0	3.0	3.0	3.0
Bone meal	1.0	1.0	1.0	1.0	1.0
Salt	2.0	2.0	2.0	2.0	2.0
Total	100.0	100.0	100.0	100.0	100.0
Calculated crude protein	35.0	35.0	35.0	35.0	35.0
Production cost(₦/1kg)	128.06	125.21	121.69	117.23	108.77
Production cost 1 bag of 45kg (₦)	5762.7	5634.45	5476.05	5275.35	4894.65

Vitamin and Minerals: Vitamin A – 10,000,000 i.U.; D3 – 2,000.000 I.U.; E – 23,000mg; K3 – 2,000mg; B1 – 3000mg; B2 – 6000mg; Nacin – 50,000mg; Calcium Pathonate – 10,000mg; B6 – 5000mg; B12 – 25.0mg; Folic acid 1,000mg; Biotin – 50.0mg; Choline chloride – 400,000mg; Manganese – 120,000mg; Iron – 100,000mg; Copper – 8,500mg; Iodine – 1500mg; Cobalt – 300mg; Selenium – 120mg; Anti-oxidant – 120,000mg.

Monitoring of Water Quality

Water temperature record was taken daily before feeding at (7.00-8.00) with graduated mercury – in-glass thermometer. Dissolved oxygen was determined by using the Winkler solution, and pH of the water was determined with pH meter (E251) weekly using the method described by Boyd (1983).

Proximate Analysis of the Experimental Diets and Fish Carcass

The water hyacinth meal, fish meal, experimental diets and fish Carcass were analyzed for the proximate composition following Association of Analytical Chemist Methods (A.O.A.C., 2000). Moisture content was determined by drying in an oven at 85^o to constant weight. Crude protein was determined indirectly from the analysis of total nitrogen (crude protein = amount of Nitrogen x 6.25) using Kjeldahl method while crude lipid was determined after soxhlet extraction of dried samples with 1.25% H_2SO_4 and 1.25% NaOH. Ash content after ashing in a porcelain crucible placed in a muffle furnace at 550^{o}C for 16 hours. Gross energy content was determined using bomb calorimeter.

Determination of Growth and Nutrient Utilization

The weekly weights recorded and feed supplied were used to compute the growth and nutrient utilization parameters following the method of Oliva – Teles and Goncalves (2001).

Mean weight gain = W_f - W_i/n

Relative Growth Rate = Weight gain x 100/Initial body weight

Specific Growth Rate = Log w_f – Log w_i x 100/t.

Food Conversion Ratio = Feed intake (g) / Fish weight gain (g).

Gross Feed Conversion Efficiency (%) = 1/Feed Conversion rate x 100

Protein Efficiency Ratio = Mean weight gain (g) / Mean protein intake.

Economic Analysis

The economic analysis was computed to estimate the cost of feed required to raise a kilogram of fish using the various experimental diets. The major assumption is that all other operating costs for commercial fish production will remain the same for all diets. Thus cost of feed was the only economic criterion in this case. The cost was based on the current prices of the feed ingredients as at the time of purchase. The cost producing water hyacinth meal was put as processing costs. The economic evaluations of the diets were calculated from the method of New (1989) as:

Estimated Investment cost analysis = Cost of Feeding (₦) + Cost of fingerlings stocked (N)

Profit Index = Value of fish (₦)/Cost of Feed (₦).

Incident of Cost = Cost of Feed (₦)/Mean weight gain of fish produced (g)

Net Profit = Total Cost of Fish cropped (₦) – Total Expenditure (₦).

Benefit: Cost ratio (Bcr) = $\dfrac{\text{Total cost of fish cropped (₦)}}{\text{Total Expenditure (₦)}}$ (Mazid *et al*., 1997).

Results

The proximate analysis of fish meal, water hyacinth mean and the five experimental diets used is presented on Table 2. The crude protein, crude lipid, ash and crude fibre ranged from 36.27%-36.6%; 4.29%-5.07%; 2.12%-7.25%; and 7.41%-7.87% respectively. There was significant difference ($P \leq 0.05$) between the proximate composition of crude lip[id and Ash content.

The weekly changes in weight has shown on Figure 1 implies that 30% water hyacinth meal inclusion levels gave the final highest weight increase as at the last sampled week. Increase in weight was recorded in all the experimental treatments. The highest total weight gain of 52.0g was recorded in fish fed 10% and 20% water hyacinth supplemented diets. The best specific growth rate of 0.84% was recorded from the control. The result of the feed conversion rate and gross feed conversion efficiency ranged between 3.57 – 3.95% and 25.52 – 28.01% respectively. The highest protein efficiency ratio of 0.83 and best condition factor of 0.72 were recorded from WH3 treatment while the highest protein productive value of 0.506 was recorded in fish fed WH5 diet. The survival rate ranged from 75% - 80%.

The best net profit of N224.07 and Cost benefit ratio of 1.31 were recorded from fish fed 30% water hyacinth meal supplemented diet.

Table 2: Proximate Composition (Dry Matter %) of Fish Meal, Water Hyacinth Meal and Experimental Diets.

Parameters	**Fish meal**	**Water Hyacinth meal**	**WH1**	**WH2**	**WH3**	**WH4**	**WH5**
			0% (Control)	**10%**	**20%**	**30%**	**40%**
Crude Protein %	70.98	13.57	36.63	36.57	36.48	36.31	36.27
Ether Extract %	4.20	4.49	5.07	4.87	4.63	4.48	4.29
Crude Fibre %	0.98	21.60	7.87	7.73	7.61	7.48	7.41
Ash %	10.03	2.71	2.12	3.04	4.09	5.47	7.25
Nitrogen free extract %	4.16	47.33	41.15	39.42	39.06	38.19	36.44
Moisture %	9.65	10.50	7.16	8.37	8.13	8.07	8.34
Gross energy kcal/100g	461.05	309.24	421.48	412.39	408.16	402.29	393.17

Discussion

The five experimental diets fed to the fingerlings for a period of ten weeks were well accepted and utilized for growth. Inclusion of water hyacinth significantly increases the crude fibre content of the feeds. This probably affected the food conversion ratio and the feed utilization by the fingerlings. High fibre in feed plays a significant role in digestion of feed (Fagbenro and Arowosegbe, 1991). The lipid component reduce as the water hyacinth inclusion levels increases; this affect the protein sparing effect which lipis has on protein utilization from the muscle development and the growth in fish (Rumsey, 1993). The crude protein of the experimental diets was close to what was reported as optimum for the culture of catfish (Fagbenro, 1992). The nitrogen free extract is an energy factor which is needed to activate metabolic process in living organisms. There is significant difference ($P \leq 0.05$) in the nitrogen free extract of the experimental diets at the each water hyacinth the inclusion levels.

There is no significant difference ($P>0.05$) between the growths of fingerlings fed diets containing 0% - 40% water hyacinth meal. This infers that inclusion of water hyacinth up to 40% significantly improved growth in *C. gariepinus*. The higher feed conversion ratio (FCR) recorded for this experiment must have been as a result of the negative impact of the anti-nutritional factors present in plant proteins. These factors have the ability to impair growth and feed utilization by fish (Balogun and Ologhobo, 1989; Eyo, 1999). The Protein Efficiency Rate (PER) correlates positively ($r=0.626$, $P<0.05$) with total weight gain computed for the experimental diets. Survival was generally high in all the fingerlings fed with the water hyacinth supplemented diets. The cost of production and the benefits positively favored all treatments since the values computed are > 1.0 which shows an increase in the fish value above the amount invested. This not withstanding, more monetary profit awaits a farmer when 30% of water hyacinth meal is used to replacement fish meal in the diets of *C. gariepinus*. This aquaculture utilization will promotes sustainable aquaculture in Nigeria and helps in the control of the nuisance water hyacinth report from the wild (Daddy *et al*., 1989).

Table 3: Growth feed utilization, survival rate, condition factors and economic indices of *Clarias gariepinus* fingerlings fed water hyacinth supplemented diets for 70 days under laboratory conditions.

Parameter/Water Hyacinth Meal inclusion Levels	**WH1**	**WH2**	**WH3**	**WH4**	**WH5**	**Mean±SEM**
	0% (Control)	**10%**	**20%**	**30%**	**40%**	
Initial mean weight (g/fish	1.30	1.28	1.20	1.20	1.30	1.26±0.023
Total initial weight (g)	26.0	25.6	24.0	24.0	26.0	25.12±0.463
Mean final weight (g/fish)	5.06	4.85	4.75	4.51	4.38	4.71±0.121
Total final weight (g)	75.90	77.60	76.00	72.16	70.08	74.35±1.39
Mean weight gain (g/fish)	3.76^{a}	3.57^{a}	3.55^{a}	3.31^{b}	3.08^{c}	3.45±0.118
Total weight gain (g)	49.90	52.00	52.00	48.16	44.08	49.23±1.47
Relative weight gain %	289.2	278.9	295.8	275.8	236.9	275.32±10.3
Mean daily weight gain (g/day/fish)	0.054	0.051	0.507	0.047	0.044	0.14±0.092
Specific growth rate (% fish/day)	0.84^{a}	0.64^{b}	0.67^{b}	0.63^{b}	0.54^{c}	0.66±0.049
Feed Conversion Ratio	3.39	3.46	3.30	3.37	3.56	3.42±0.044
Gross efficiency conversion rate%	29.50	28.90	30.30	29.67	28.10	29.29±0.37
Protein Efficiency Rate	0.80	0.80	0.83	0.76	0.78	0.79±0.012
Protein productive value	0.438^{a}	0.457^{a}	0.478^{b}	0.499^{b}	0.506^{b}	0.476±0.01
Survival %	75.0	80.0	80.0	80.0	80.0	79.0±1.0
Initial condition factor (k_1)	1.15	1.50	1.25	1.30	1.28	1.296±0.06
Final condition factor (k_2)	0.82^{d}	1.91^{a}	0.72^{c}	0.91^{c}	1.02^{b}	1.076±0.21
Cost of stocked fingerlings (₦)	300.00	300.00	300.00	300.00	300.00	
Cost of feeding (₦)	239.61	246.21	225.94	207.73	18955	221.81±10.4
Other expenses incurred (₦)	200.00	200.00	200.00	200.00	200.00	
Total expenditure (₦)	739.61	746.21	725.94	707.73	689.55	
Value of fish cropped (₦)	865.38^{c}	909.38^{b}	950.01^{a}	902.01^{b}	808.62^{d}	887.08±23.8
Net Profit	125.77^{d}	163.17^{c}	224.07^{a}	194.28^{b}	119.07^{d}	165.27±18.0
Profit/individual fish (₦/fish)	8.38^{d}	10.20^{c}	14.00^{a}	12.14^{b}	7.44^{d}	10.43±1.20
Incidence of cost (₦/g)	3.16^{c}	3.17^{c}	2.97^{b}	2.88^{b}	2.70^{a}	2.98±0.89
Profit index	3.61^{c}	3.69^{c}	4.10^{ab}	4.34^{a}	4.27^{a}	4.00±0.15
Benefit: Cost ratio (Bcr)	1.17^{bc}	1.22^{b}	1.31^{a}	1.27^{b}	1.17^{bc}	1.23±0.028

References

Arowosegbe, I.A. (1987). Nutritive implication of cottonseed meal in the diet of *Clarias lazera*. Ph.D. Thesis, University of Ibadan, Ibadan, 242p.

Association of Analytical Chemists (2000). Official Methods of Analysis, 17th Edition, Washington, D.C.; U.S.A.

Balogun, A.M. and Ologhobo, A.D. (1989). Growth performance and nutrient utilization of *C. gariepinus* (Burchell, 1822) fed raw cooked soybean diets. Aquaculture 76, 119 – 126.

Boyd, C.F. (1979). Water quality management in warm water fish ponds. Auburn University of Agricultural Experimental Station, Alabama, 359pp.

Edwards, P. (1980). Food Potential of Aquatic Macrophytes. ICLARM Stud. Review, International Centre for Living Resources management, Manila, Philippines, 5:51.

Eyo, A.A. (1999). The effect of different methods of soybean processing on the growth and food utilization oof African Mudcatfish *Clarias angulliaris* (L.) fingerlings. Nig. J. Biotech. 10, (1): 9-18.

Fagbenro, O.A. (1992). Quantitative dietary protein requirements of *Clarias isheriensis* (Synderham, 1988) (Clariidae) fingerlings. Journal of Applied Ichthyology 8: 164-169.

Fagbenro, O.A. and Arowosegbe, I.A. (1991). Utilization of agricultural wastes and by-products in fish feeds production in Nigeria. Proceedings of the 6th Annual Conference of Fisheries Society of Nigeria, Lagos, pp. 121-130.

Falayi, B.A. (2003). Techniques in Fish Feed Manufacture. In Proceeding of the Joint Fishery Society of Nigeria / National Institute for Freshwater Fisheries Research/Special programme for food security National workshop on Fish feed development and feeding practices in aquaculture (Eyo, A.A. Ed). Held at National Institute for Freshwater Fisheries Research, New Bussa, 15th – 19th September, 2003, pp. 43 – 55.

Fang, Y.X.; Guo, X.Z.; Wang, J.K. and Liv, Z.Y. (1986). Effects of different animal manure on fish farming. In: The Asian Fisheries Forum (J.I. Madean Ed.) Asian Fish Soc. Manila, Philippines, pp. 117 – 120.

Hogendoorn, H. (1981). Controlled propagation of the African Catfish (*Clarias lazera*, C&V): Effect of feeding regime in fingerlings culture. Aquaculture 24: 123 – 131.

Igbinosun, O.R. and Amako, D. (1988). Investigation into probable use of water hyacinth (*Eichornia cassipes*) in Tilapia feed formulation. Nigeria Institute for Freshwater Fisheries Research Technical Paper, 39: 3-9.

Kusemiju, K. (1988). Strategies for effective management of water hyacinth in the creeks and lagoons of south-western Nigeria. In: Oke, K.L.; A.M.A. Imevbore and T.A. Farri, Op.cit., 39-45.

Kusemiju, K. and O.S. Akingboju (1988). Comparative growth of sarotherodon melanotheron (Ruppell) on formulated fish feed and water Hyacinth diets. Op.cit., 196-203.

Mazid, M.A.; Zaher, M.; Begum, N.N.; Aliu, M.Z.; Nahar, F. (1997). Formulation of cost-effective feeds from locally available ingredients for carp polyculture system for increase production. Aquaculture 151: 71-78.

New, M.B. (1989). Formulated aquaculture feeds in Asia: Some thoughts on comparative economics, industrial potential, problems and research needs in relation to small-scale farmer. In: Report of the Workshop on Shrimps and Fin Fish Feed Development (Bahru, J. Ed.). ASEAN/SF/89/GEN/11.

Rumsey, G.L. (1993). Fish meal and alternative sources of Protein. Fisheries 18: 14-19.

Trelo-ges, V.; Ruaysoongnern, S.; Chuasavathi, T. (2002). Effect of earthworm activities (*Pheretema* sp.) on the changes in soil chemical properties at different soil depth of Nampong soil series (Uscoxic Quartzisamment) in Northeast Thailand. Pakistan Journal of Biological Sciences 5(1): 32-35.