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Digestibility Value and Nutrient Utilization of Water Hyacinth (*Eichhornia crassipes*) Meal as Plant Protein Supplement in the Diet of *Clarias gariepinus* (Burchell, 1822) Juveniles

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Abstract: Whole water hyacinth plant meal (WPM), water hyacinth leaf meal (WLM) and soya bean meal (SBM) were used to compound three isoproteic (40% crude protein) fish rations. Catfish of 11.2±0.3g average weight were fed test diets in triplicates for 70 days. Data were collected forthnightly on fish growth performance and water qualities (dissolved oxygen, pH, ammonia and temperature) parameters. Fish, feeds and faecal wastes were analyzed chemically and data were subjected to ANOVA. Crude protein of WLM (28.20%) was higher than that of WPM (24.17%) while cude fibre was higher in WPM than in WLM ($p<0.05$). Fish fed SBM-based diet had superior performance over those fed WHM-based diets with respect to Weight gain, Specific growth rate, Protein efficiency ratio, Feed conversion ratio, Nitrogen metabolism and digestibility coefficients. Fish fed WLM showed significant nutrient utilization performance over those fed WPM with respect to all the parameters considered. The significant difference in the nutrient utilization assessment and weight gain of fish could be as a result of high fibre content present in WPM. Significantly low value of ammonia was recorded in water under WPM treatment (0.18±0.06 mg/l) while WLM and SBM treatment had 0.46±0.13 mg/l and 0.71±0.10 mg/l values of ammonia respectively. These observations may be due to the presence of higher fibre content in the WPM than other meals and consequently high potential for aquaculture wastewater treatment. Water hyacinth leaf meal (WLM) would therefore serve a better option for ensuring maximum utilization for sustainable fish production and biodiversity conserving.

Key words: Catfish · Growth parameters · Water purification · Sustainable fish production · Biodiversity

INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) is an aquatic plant which can live and reproduce floating freely on the surface of fresh waters or can be archored in mud making it the most successful colonizer in the plant world [1]. The extremely rapid rate of proliferation [2] of the water usually result in reduction in height penetration and dissolved oxygen in water bodies, change water chemistry, affect flora and fauna, increase rate of water loss due to evapotranspiration and it is now presently being considered as a serious threat to biodiversity [3]. Recently, considerable attention has been given to its harvesting for practical uses, namely, for partially defraying the cost of removing plants from water ways and for use as alternative plant protein source in livestock feed including fish [4, 5]. The reports of Boyd [6, 7] on the chemical analyses of water hyacinth indicated that it contains very high fibrous or cell wall materials, mainly cellulose which was corroborated by [8] but very rich in amino acid profile [9]. The high fiber content of the whole water hyacinth plant meal has put great limitations into its effective utilization by fish as feed ingredient [8, 10] despite its high nutritive value. The present study was conducted to assess digestibility of whole water hyacinth plant meal (WPM) and its leaf meal (WLM) by African catfish (*Clarias gariepinus*) being a commercially viable fish species in Nigeria.

MATERIALS AND METHODS

The study was conducted at the Postgraduate Laboratory of the Department of Wildlife and Fisheries Management, University of Ibadan, Ibadan, Nigeria.

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Collection and Processing of Water Hyacinth: Water hyacinth plant was collected fresh from Awba dam of the University of Ibadan. The plant was thinly spread on a slab for solar drying for two weeks during which it was regularly turned to ensure homogenous drying. Approximately 500g of the leaf were collected by separation from the petiole of the plant. The collected leaves were ground into a fine meal with a Willey Mill using a 0.1mm mesh screen which served as water hyacinth leaf meal (WLM). Whole plant of water hyacinth was also prepared into meal (WPM) by grinding whole plant into fine meal with a Willey Mill using 0.1mm mesh screen. The two meals were analyzed for crude protein, ash, crude lipid and crude fiber.

Preparation of Experimental Diets and Proximate Analysis: Three (3) practical isoproteic {40% crude protein (CP)} diets were prepared using the two water hyacinth meals (WPM and WLM) and soybean meal (SBM) as control. Fishmeal, groundnut cake and the three meals were the main dietary protein sources while mineral/vitamin premix was added to further enhance the nutritional quality of the diets. Allowance was made to accommodate 1% chromic oxide in each of the diets which served as marker. All diets were chemically analyzed for their crude protein, ash crude fiber and crude lipid.

Digestibility Study: A total of 90 catfish fingerlings of 11.2 ± 0.3g average weight were randomly distributed into 9 concrete tanks of with 150L capacity. Water was regularly supplied with deep well at a flow rate of approximately 2 L min continuously for 10 weeks when the experiment was terminated. Temperature of water was taken daily with a graduated mercury-in-glass thermometer before feeding. Dissolved oxygen, pH and ammonia were monitored using combined digital (YSI) meter forth nightly during which tank water was renewed. During the study period, fish were fed twice a day (08:00 and 18:00 hours) until apparent satiation and the amount of feed intake in each tank was recorded per daily. Faeces were collected from each tank daily before feeding and at 8 hours after feeding by siphoning with rubber tube. They were oven dried at 48°C. Faecal wastes were also collected from each treatment 8 hours after feeding on the last day by rectal dissection method as described by [11]. Samples of experimental fish were killed and analyzed for proximate composition before and after experiment. All meals, diets, fish samples and faecal wastes were chemically analyzed for their proximate composition according to the methods of AOAC [12]. Survival rate of fish were determined in each treatment at the end of experiment.

Determination of Growth, Nutrient Utilization and Digestibility Coefficient: The fortnight weights of fish per unit recorded and quantity of feed consumed by fish were used to compute the following growth and nutrient utilization parameters:

- Mean weight gain (MWG) = W_2g - W_1g
- Weight gain (MWG) = $W_2 - W_1$
- Specific Growth Rate (SGR) = (Log W_2 – Log $W_1/T_2 - T_1$) x 100

Where: W_2 = final weight of fish, W_1 = initial weight (g) of fish, T_2 = end of experiment and T_1 = beginning of experiment (days)

- Protein efficiency ratio (PER) = weight gain (g)/Protein intake (g)
- Feed conversion Ratio (FCR) = Total feed intake/Weight gain (g)
- Protein intake = Feed fed x crude protein of the feed.
- Nitrogen Metabolism (Nm)=(0.549) (a+b) h/2 where; a =initial mean weight of fish, b= Final mean weight of fish and h=Experimental period in days.
- Apparent digestibility coefficients (ADC) = 10^2 – (10^2 x (1d/1f x Nf/Nd) where, Nd= Protein in diet. Nf = protein in faces. 1d=%Cr_2O_3 in diet and 1f=%Cr_2O_3 in faeces.
- Survival rate (%) = (Initial no. of fish stocked – mortality)/Initial no. of fish x 100.

Statistical Analysis: Three replicates were assigned to each dietary treatment using a completely randomized design. Data collected were subjected to analysis of variance test (ANOVA) using statistical package for the social science (SPSS) computer software 1988 version 10.0 of the Chicago Illinois (USA). Significant mean differences were separated at 0.05 probability level using the methods of Steel *et al.*, [13].

RESULTS

Table 1 presents the proximate composition of water hyacinth plant meal (WPM) and its leaf meal (WLM) used for the study. Values of crude protein and crude fat were higher in WLM (28.20% and 4.70%) than those of WPM which are 24.17% and 2.37% respectively. The crude fiber content of WPM (19.62%) was however higher than that

Table 1: Proximate composition of water hyacinth meals (WHMs)

WHMs	Crude protein (%)	Crude lipid (%)	Crude fibre (%)	Ash (%)	NFE (%)
WPM	24.17	2.37	19.62	11.35	42.49
WLM	28.20	4.70	14.79	7.03	45.28

Table 2: Gross and proximate composition of experimental diets (g/100/DM)

	Diets		
Ingredients	1	2	3
Fishmeal	18.94	18.94	18.94
Groundnut cake	26.97	26.97	26.97
Soyabean meal	22.91	-	-
Water hyacinth plant meal (WPM)	-	26.72	-
Water hyacinth leaf meal (WLM)	-	-	31.63
Yellow maize	25.18	21.37	16.46
Bone meal	1.00	1.00	1.00
Vit. Premix	2.50	2.50	2.50
Fish oil	1.50	1.50	1.50
Cr_2O_3	1.00	1.00	1.00
Proximate composition (g/100g/DM)			
Crude protein	40.13	40.08	40.11
Crude fibre	4.38	6.47	5.51
Crude fat	7.14	4.21	4.86
Ash	4.62	6.11	6.30
NFE	43.73	43.13	43.22
Gross Energy(Kcal/g/DM)	328.16	326.32	329.25

Table 3: Growth performance and nutrient utilization of *C. gariepinus* fed SBM and WHM based diets

	Diets			
Parameter	1(SBM)	2(WPM)	3(WLM)	SEM
Initial MW (g)	11.17^a	11.23^a	11.21^a	0.03
Final MW (g)	34.25^a	26.02^c	30.34^b	0.31
MWG (g)	23.08^a	14.79^c	19.13^b	0.44
WG (%)	67.38^a	56.84^c	63.05^b	4.03
Total feed intake (g)	76.43^b	79.64^a	80.11^a	3.27
SGR (%)	0.70^a	0.52^c	0.62^b	0.14
Protein intake (g)	4.37^b	4.55^a	4.58^a	0.05
PER	5.28^a	3.25^c	4.18^b	0.03
FCR	3.31^c	5.38^a	4.19^b	0.07
Nm	8.73^a	7.16^c	7.98^b	0.08
NPU	1.86^a	1.25^c	1.54^b	0.03
ADC protein	76.14^a	65.44^c	71.28^b	2.06
ADC energy	73.02^a	63.16^c	67.30^b	1.74
Survival rate (%)*	100	100	100	-

Values with the same superscript along the same row are not significant different (p>0.05).

* value not analyzed statistically.

Table 4: Fish carcass proximate composition before and after 10-week feeding trail

		Final		
Parameter (%)	Initial	Diet 1(SBM)	Diet 2 (WPM)	Diet 3 (WLM)
Crude protein	61.62 ± 0.03^d	$64.77+0.04^a$	62.43 ± 0.01^c	63.50 ± 0.02^b
Crude fat	4.55 ± 0.11^d	$9.52+0.03^a$	8.21 ± 0.06^c	8.96 ± 0.04^b
Crude fibre	ND	ND	ND	ND
Ash	10.61 ± 0.16^a	$8.22+0.02^b$	7.43 ± 0.01^c	7.67 ± 0.03^c
Moisture	23.22 ± 0.77^a	$17.49+0.54^d$	21.93 ± 0.38^b	19.87 ± 1.02^c

Values with the same superscript along the same row are not significant different (p>0.05)

ND: Not Detected

Table 5: values of water quality parameters assessed during digestibility study

		Final values		
Parameters	Initial value	Diet 1(SBM)	Diet 2(WPM)	Diets (WLM)
Temp.(°C)	27.86±0.13[a]	27.85±0.22[a]	27.92±0.10[a]	27.88±0.15[a]
pH	7.40±0.11[a]	6.82±0.14[c]	6.98±0.05[b]	6.91±0.09[b]
DO_2 (Mg/L)	6.36±0.20[a]	5.46±0.11[b]	5.27±0.03[c]	5.48±0.02[b]
Ammonia (Mg/L)	0.13±0.04[d]	0.71±0.10[a]	0.18±0.06[c]	0.46±0.13[b]

Values with the same superscript along the same row are not significant different (p>0.05).

of WLM (14.79%). Gross composition of the three test diets used in the study and their proximate compositions were presented in Table 2. Values of crude protein from proximate analysis slightly deviated from 40% with a range of 0.05 while crude fat ranged between 4.21% and 7.14% in diets 2 and 1 respectively. Crude fiber was however found to be conspicuously high in diets 2 (6.47%) followed by diets 3 (5.51%) while the least value of crude fiber content was recorded in diet 1 (4.38%), which was a soyabean meal (SBM) based diet. Mean weight gain (MWG) was significantly different among fish under all treatment ($p<0.05$). Fish fed diet 1 had highest MWG (23.08g) while the least MWG value recorded (14.79g) was for fish fed diet 2. Specific growth rate (SGR) was highest in fish fed diet 1 and least in diet 2 and percentage mean weight gain also followed the same trend. Total feed intake and protein intake were both significantly higher in fish fed diets 2 and 3 than in fish fed diet 1. However, values of PER, Nm and NPU were all significantly higher in diet 1 than values in diet 2 and 3 ($p<0.05$) except for values of FCR which was least in diet 1 (3.31) but highest in diet 2 (5.38) significantly. Apparent digestibility coefficient (ADC) of protein and energy were significantly highest in diet 1 (76.14 and 73.02) followed by diet 3 (71.28 and 67.30) while diet 2 had the least ADC of 65.44 and 63.16 for protein and energy respectively. Survival rate of experimental fish was 100% in all treatments at the end of the 70 day digestibility study as presented in Table 3 while their carcass proximate composition was presented in Table 4. Temperature of water was only marginally different in all treatment durng the study but values of pH had significant variation ($p<0.05$). Initial pH of water (7.40±0.11) fluctuated in all treatments and ranged between 6.91±0.09 in diet 3 to 6.82±0.14 in diet 1. Dissolved oxygen was high in all treatment and they all varied significantly from initial value of 6.36±0.20 (mg/L) to 5.27±0.03 (mg/L) in diet 2. Values of ammonia varied significantly in all treatments ($p<0.05$). Diet 2(WPM) had the least value (0.18±0.06 mg/L) of ammonia among the treatments while the highest values of ammonia (0.71± 0.01mg/l) was recorded in diet 1 (SBM) with the initial value being 0.13+0.04 mg/l as shown in Table 5.

DISCUSSION

The results of the proximate analysis of the water hyacinth meals showed that both the leaf meal (WLM) and whole plant meal (WPM) can be used as dietary protein source [14] despite the variation in their crude protein contents. The subsequent variations between values of their crude fibers and crude fat may be due to the concentration of nutrients at varying levels in different parts of plants as earlier reported by [8] on *Eichhornia crassipes* and [15] on *Leucaena leucocephala*. Mean weight gain was highest in fish fed SBM-based diet (Diet 1) with the least values for fed intake. The significantly low weight gains and SGRs in fish fed diets containing water hyacinth meals may be due to the high fiber content present in the plant. These results are in line with the reports of [16] on the growth and blood parameters of catfish fed dietary water hyacinth meal. The significant variations observed between MWG, SGR, FCR,PER and Nm of dietary WPM and WLM could be due to the high fiber content of whole water hyacinth plant meal (WPM) compared with that of the leaf meal (WLM). This observation seems to corroborate the report of [17] on the effect of presence of certain substances in feed ingredients such as crude fiber content that limit utilization. This is obvious from the justification of the recommendation of [5] that water hyacinth meal needs further processing in order to bring its fiber content to the lowest possible level and consequently improve its digestibility. The significantly higher digestibility coefficients of SBM-based diet (diets 1) is not surprising being a conventional feed ingredient and having excellent nutrient utilizations in terms of the growth parameters assessed but a clear evidence of significantly better performance and higher digestibility values of protein and energy of WLM over WPM showed that separation of the leaves of water hyacinth from the petiole to prepare meals should be encouraged in order to maximize its utilization in fish production. The increasing trend in fish carcass protein and crude fat were however expected and this further showed that WHMs had positive utilization effects in catfish diet. The positive utilization effect expressed coupled with high feed intake and 100% survival rate seem to imply that high fiber content is the only limitation to the use of water hyacinth meal in fish production. This observation is related to the reports of [5] and [8] who had earlier reported high fiber content as the limitation to the utilization of water hyacinth meal in their respective studies.

Despite the short comings of high fiber content in diet 2 (whole water hyacinth plant meal-based diet), fish under the treatment seem to be in a better culture medium as the ammonia content was greatly reduced followed by fish under diet 3 treatments (water hyacinth leaf meal). The presence of WHMs in the diets appears to provide a better environment for culture than diet 1 which has no WHM. This observation is in line with the reports of [18-22] who revealed the potentials of water hyacinth in waste water treatment.

CONCLUSION

This study revealed that water hyacinth meal has a positive nutrient utilization effect on fish growth and that it can assist fish farmers in ensuring sustainable fish production through production of least-cost diets. The sustainability of the least-cost diet is expected to eventually translate into successful management of the weed in our water ways and ensure protection of biodiversity. Massive mechanical harvest of the weed should be advocated and effective information dissemination about utilization of the leafy part alone in fish feed production should also be carried out. This is recommended so that more of the plant is utilized in fish feed production coupled with its water purifying potential despite having undergone some processing. However, further study is suggested on the relationship of the structural properties of the plant before processing (grinding) and after grinding and it potential in the purification or treatment of aquaculture waste water.

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