DIGESTIBILITY AND PERFORMANCE OF WATER HYACINTH MEAL IN THE DIETS OF AFRICAN CATFISH (*Clarias gariepinus*; BURCHELL, 1822).

[DIGESTIBILIDAD Y COMPORTAMIENTO DEL BAGRE AFRICANO (*Clarias gariepinus*; BURCHELL, 1822) CON DIETAS DE JACINTO DE AGUA]

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SUMMARY

Water hyacinth meal (WHM) as an alternative protein source was investigated in this study. 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 diets. Catfish of 11.2 ± 0.3g average weight were used for the 70-day digestibility study. Data were collected forthnightly on fish growth performance and water qualities (dissolved oxygen, pH, ammonia and temperature). Fish, feeds, and faecal wastes were analyzed. Fish fed SBM-based diet had superior performance over those fed WHM-based diets with respect to Mean weight gain (MWG), Specific growth rate (SGR), Protein efficiency ratio (PER), Feed conversion ratio (FCR), Nitrogen metabolism (Nm) and digestibility coefficients (ADC). Fish fed all diets exhibited marginal difference in total feed intake but growth performance and nutrient utilization were significantly higher in fish fed WLM than fish fed WPM probably as a result of high fibre content present in WPM. Extremely low value of ammonia was recorded in water under WPM treatment (0.18±0.06 mg/l) while water under WLM and SBM treatment had significantly higher values of ammonia 0.46± 0.13 mg/l and 0.71± 0.10 mg/l respectively. These observations may be due to the presence of significantly higher fibre content in the WPM than other meals. Consequently this could be responsible for its poor digestibility values but high potential for waste water purification. Water hyacinth leaf meal (WLM) would therefore serve a better option for adoption in ensuring maximum utilization potentials of the aquatic plant both for profitable and sustainable fish production.

Key words: Catfish; Water hyacinth; Fish feed; Water purification; Fish production.

RESUMEN

Se evaluó el uso de harina de jacinto de agua (WHM) como una fuente alternativa de proteína. Harina de planta completa (WPM), de hoja (WLM) y pasta de soya (SBM) fueron empleados para elaborar 3 dietas isoproteicas (40% proteína cruda). Se emplearon bagres de 11.2 ± 0.3g de peso para un estudio de digestibilidad de 70 d. Se recolectó información en crecimiento y calidad del agua (oxígeno disuelto, pH, amonía y temperatura). Se analizaron los peces, alimentos y residuos fecales. Los peces alimentados con SBM tuvieron un mejor desempeño que aquellos alimentados con WHM. Los consumos fueron marginalmente diferentes, pero el crecimiento y utilización de nutrientes fue mayor en WLM que en WPM probablemente como resultado del alto nivel de fibra de WPM. Se observó un nivel muy bajo de amonia en WPM en comparación con WLM y SBM (0.18±0.06, 0.46± 0.13 y 0.71± 0.10 mg/l respectivamente). La harina de hoja de Jacinto de agua puede ser una buena opción rentable para la producción de peces.

Palabras clave: Bagre; lirio de agua; alimento peces; purificación de agua; producción de peces.

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 anchored in mud making it the most successful colonizer in the plant world (Wolverton and McDonald, 1979). The extremely rapid rate of proliferation (Garry *et al*, 1997) of the water usually result in reduction in light 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 (Mathur, 2007). 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 (Daddy, 2000; Sotolu, 2008; Aderolu and Akinremi, 2009). The reports of Boyd (1968, 1969) on the chemical analyses of water hyacinth indicated that it contains very high fibrous or cell wall materials, mainly cellulose which was corroborated by Igbinosun *et al*. (1988) but very rich in amino acid profile (Wolverton and McDonald, 1978). The high fibre content of the whole water hyacinth plant meal has put great limitations into its effective utilization by fish as feed ingredient (Igbinosun *et al*. 1988: Nwanna *et al*, 2008) despite its high nutritive value. *Clarias gariepinus* is a major fish species for aquaculture in African and it has also been introduced in Europe and Asia (Fagbenro and Davies, 2001). It is cultured for its high growth rate resistance to handling and stress, omnivorous feeding habit as it readily accept different kinds of unconventional feed ingredients included in its diet (Faturoti 2000; Fasakin 2008). 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 Department of Wildlife and fisheries Management postgraduate Laboratory of the University of Ibadan, Ibadan, Nigeria.

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 dried leaves 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 500g 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 fibre (Table 1).

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

Preparation of Experimental Diets and Proximate Analysis

Three practical isoproteic {40% crude protein (CP)} diets were prepared using the two water hyacinth meals (WPM and WLM) and soybean meal (SBM). SBM was used 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 fibre and crude lipid (Table 2).

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
Nitrogen free extract (NFE)	43.73	43.13	43.22
Gross Energy(Kcal/g/DM)	328.16	326.32	329.25

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. Three replicates were assigned to each dietary treatment using a completely randomized design Water was supplied by deep well at a flow rate of approximately 2 L min continuously for 10 weeks. 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 forthnightly during which water in the tanks was completely changed. During the study period, fish were fed twice daily (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^oC for 120 hours. Faecal wastes were also collected from each treatment 8 hours after feeding on the last day by rectal dissection method as described by Hetch *et al* (1988). Samples of fish were taken at the beginning and at the end of the experiment for proximate analysis. All meals, diets, fish samples and faecal wastes were chemically analyzed for their proximate composition according to the methods of AOAC (2000). 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 according to Aderolu *et al*. (2009).

1. Mean weight gain (MWG) = W_2g - W_1g
2. Weight gain (MWG) = $W_2 – W_1$
3. 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).

4. Protein efficiency ratio (PER) = weight gain (g)/Protein intake (g)
5. Feed conversion Ratio (FCR) = Total feed intake/Weight gain (g)
6. Protein intake = Feed fed x crude protein of the feed.
7. 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.
8. 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.
9. Survival rate (%) = (Initial no. of fish stocked – mortality)/Initial no. of fish x 100.

Statistical analysis

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). All data collected were subjected to one way analysis of variance (ANOVA) according to Steel *et al* (1997). Comparisons among treatment means was carried out by Duncan Multiple Range test (Duncan, 1955) at a significance level of 0.05.

RESULTS

Table 1 presents the proximate composition of water hyacinth plant meal (WPM) and its leaf meal (WLM) used in the replacement of soyabean meal in 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 fibre content of WPM (19.62%) was however higher than that 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 fibre was however found to be conspicuously high in diet 2 (6.47%) followed by diet 3 (5.51%) while the least value of crude fibre 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 the 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). 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 is presented in Table 4. Temperature of water was only marginally different in all treatment during 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 6.82±0.14 in diet 1 to 6.91±0.09 in diet 3. Dissolved oxygen was high in all treatment and they all varied significantly from initial value of 6.36±0.20 (mg/l). 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.

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

Parameter	**Diets**		
	1(SBM)	**2WPM)**	**3(WLM)**
Initial MW (g)	11.17 ± 0.18^a	11.23 ± 0.14^a	11.21 ± 0.16^a
Final MW (g)	34.25 ± 1.16^a	$26.02\pm1{,}07^c$	30.34 ± 1.05^b
MWG (g)	23.08 ± 1.07^a	14.79 ± 1.14^c	19.13 ± 1.10^b
WG (%)	67.38 ± 0.77^a	56.84 ± 0.64^c	63.05 ± 0.85^b
Total feed intake (g)	76.43 ± 2.05^b	79.64 ± 2.11^a	80.11 ± 2.14^a
SGR (%)	0.70 ± 0.02^a	0.52 ± 0.03^c	0.62 ± 0.02^b
Protein intake(g)	4.37 ± 0.02^b	4.55 ± 0.02^a	4.58 ± 0.01^a
PER	5.28 ± 0.01^a	3.25 ± 0.01^c	4.18 ± 0.02^b
FCR	3.31 ± 0.08^c	5.38 ± 0.10^a	4.19 ± 0.13^b
Nm	8.73 ± 0.36^a	7.16 ± 0.42^c	7.98 ± 0.44^b
NPU	1.86 ± 0.02^a	1.25 ± 0.02^c	1.54 ± 0.03^b
ADC protein	76.14 ± 1.72^a	65.44 ± 1.15^c	71.28 ± 1.02^b
ADC energy	73.02 ± 0.86^a	63.16 ± 0.66^c	67.30 ± 0.73^b
Survival rate (%)*	100	100	100

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

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 (NRC 1993) despite the variation in their crude protein contents. The subsequent variations between values of their crude fibres and crude fat may be due to the concentration of nutrients at varying levels in different parts of plants as earlier reported by Igbinosun *et al*. (1988) on *Eichhornia crassipes* and Akbar and Gupta (1985) on *Leucaena leucocephala*. Mean weight gain was highest in fish fed SBM-based diet 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 fibre content present in the plant. This observation is in line with the reports Nwanna *et al.* (2008) who reported poor fish growth performance when fed diet with crude fibre above 4.7%. These results are in line with the reports of Nwanna and Ajani (2005) 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 fibre content of whole water hyacinth plant meal (WPM) compared with that of the leaf meal (WLM) even though both diets contained crude fibre greater than the limit suggested by Nwanna *et al.* (2008). This observation seems to corroborate the report of Alceste and Jory (2000) on the effect of presence of certain substances in feed ingredients such as crude fibre content that limit diets utilization. Based on several reports on the utilization of water hyacinth, Nwanna *et al.* (2008) was reported to have recommended further processing of hyacinth meal in order to bring its crude fibre content to the lowest possible level and consequently improve its digestibility.

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

Parameter (%)	**Final**			
	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

The significantly higher digestibility coefficients of SBM-based diet is not surprising being a conventional feed ingredient and having excellent nutrient utilizations in terms of the growth parameters assessed. There was a clear evidence of significantly better performance and higher digestibility coefficients of protein and energy for WLM over WPM. This 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. This positive utilization effect expressed coupled with high feed intake and 100% survival rate seem to imply that high fibre content is the only limitation to the use of water hyacinth meal in fish production. This observation is related to the reports of Sotolu (2008) and Sotolu and Adejumoh (2009). Despite the short comings of high fibre 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 live with the reports of Thyagarajan (1984), Balasooriya *et al.* (1984) and Addison (1997).

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 leaf meal of the water hyacinth is more suitable for fish production than the whole plant meal and its prominent use in aquafeed production is viewed to be capable of serving dual purpose of least-cost diet for sustainable fish farming and a way of successful management of the weed in our water ways. Massive mechanical harvest of the weed should therefore be advocated and effective information dissemination about utilization of the leafy part alone in fish feed production should also be carried out especially to poor fish farmers who depends on locally available input for fish production. This is recommended so that more of the plant is utilized in fish feed production coupled with its water purifying potential even after grinding. 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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