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Full Length Research Paper

Nutritional Potentials of Water Hyacinth (*Eichhornia crassipes)*

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The study investigated the nutritional potentials of Eichhorniacrassipes, commonly known as water hyacinth. Proximate analysis showed that the leaf contained the highest percentage of crude protein (21.44+1.15%), followed by the stem (9.04±0.51%), with the least being in the root (6.86 ± 0.67%). The total carbohydrate was highest in the leaf (17.86±0.17%). The highest crude fibre content was observed in the stem (57.99±1.14%) while that of the root (24.47± 0.90%) was the lowest. All these values were significantly different ($p<0.05$) in the leaf, stem and root. The anti-nutrient composition showed that the leaf had the highest content of tannin (991.36±0.00mg/100g) and oxalate (9.63±0.00mg/100g) while the stem recorded the lowest values in tannin (706.01±0.00mg/100g) and oxalate (5.14±0.00mg/100g). In the vitamin profile, vitamin C was the most abundant, with its content being the highest in the stem (216.61±0.00mg/100g) and lowest in the leaf (204.80 ± 0.00). Vitamin D was the least, with its highest content in the root (6.28 x 10^{-6}±0.00mg/100g) and lowest in the stem (3.63 x 10^{6}±0.00mg/100g). Amongst the essential amino acids, in the amino acid profile, leucine was found to be the highest in the leaf (7.02±0.00mg/100g), stem (8.08±0.00mg/100g) and root (8.69 ± 0.00mg/100g), while methionine was present in relatively lower levels. The non- essential amino acids profile had glutamine as the highest in content in the leaf (15.13±0.00mg/100g), stem (11.95±0.00mg/100g) and root (15.12±0.00mg/100g), while cysteine was the least for all. These results indicate the nutritional potentials of the leaf, stem and root of the Eichhorniacrassipes plant.

Keywords: *Eichhornia crassipes,* essential amino acid, nutritional potentials, vitamin

INTRODUCTION

Aquatic plants, e.g water hyacinth (*Eichhornia crassipes*) impact both positive and negative effects on man, either directly or indirectly (Mitchell, 1974). Aquatic plants are considered nuisance when excessive growth interferes with desired water uses in a number of ways (Adeniji, 1979). In line with increased industrialization, travel and communication, agricultural productivity and changes in consumption, problems associated with aquatic plants have increased in the last century (Davis and Hirji, 2003). Enrichment of water bodies by poor land use practices, effluents from human and industrial wastes have aggravated the negative impacts of aquatic plants. Recent research indicates that aquatic plants are threats to biological diversity affecting fish fauna, plant diversity, fresh water life and food chains (Garry *et al*., 1997).Aquatic plants offer a variety of products and services which are of considerable benefits. Agriculturally, they are used as food fodder, feed ingredients, fertilizers etc. They are also used in the production of biofuel, paper, fibre board, yarn, rope, basket, charcoal briquetting, matting and bedding. Their strands act as filters for excessive nutrients, also making it possible for them to remove heavy metals, biocides and other toxins from water. Recreation and horticulture have also been enhanced by great potentials of aquatic plants. The paucity of knowledge concerning the productivity of aquatic plants emphasizes the urgent need to study these plants for their adequate management and utilization. It is on this premise, that this study was embarked upon to evaluate the nutritional potentials of the leaf, stem and root of *Eichhornia crassipes*.

MATERIALS AND METHODS

Sources of materials

Figure 1 (a) (b) (c)

The *Eichhornia.crassipe*s (Figure 1 (a, b and c) used for the work were obtained from the New Calabar River also known as Choba River, located in Obio/Akpor Local Government Area of Rivers State, South-South Nigeria.

Processing of samples

The plant was harvested from the river, cleaned and separated into the different parts (leaf, stem and root). Each part was separately oven-dried ground and stored in air tight containers**.**

Diet formulation

Five (5) diets were formulated using the *Eichhornia crassipes* leaves, stems, roots, corn starch, palm oil, non-nutritive cellulose, vitamin and mineral mixture, sucrose and Nutrend (standard feed).
Diet 1 - Reference (control) diet
Diet 2 - *Eichhorniacrassipes* leaf diet
Diet 3 - *Eichhorniacrassipes* stem diet
Diet 4 - *Eichhorniacrassipes* root diet
Diet 5 - Basal diet

Vitamins profile

Vitamins A, B, B_2, B_3, B_5, B_6, B_9, C, D, E, Kwere estimated by the gas chromatographic method of AOAC, (2006).

Amino acid profile

The amino acids were estimated by the gas chromatographic method of AOAC, (2009).

Proximate analyses

The moisture, ash, crude fibre, crude protein, crude fat (lipid) contents were determined by the method of Association of Official Analytical Chemists, AOAC (1990). Carbohydrate content was determined by the Clegg Anthrone method (Clegg, 1956) while the energy value was determined using the Atwater factors.

Method of data analysis

All samples were analyzed in triplicates. The data were analyzed using tables, range, means, percentages, standard deviation and hence standard error (SE). Sample mean was calculated for all the three replicate samples, while standard deviation (S.D) was calculated from the sample mean by the standard statistical method for all the variables. The standard deviations were used to calculate the standard errors (±S.E) as reported by Osuji *et al*, 2005. Standard error (±S.E) was estimated at the 95% confidence level. The proximate composition data obtained from this study was subjected to one-way analysis of variance (ANOVA) at 5% level of confidence using Genstat 9th edition software as reported by Ndlovu and Afolayan, (2008).

RESULTS AND DISCUSION

The highest value for moisture content of *Eichhorniacrassipes* samples was 11.70 ± 0.35% in the leaf, which was significantly (p<0.05) different from that of the stem and root. The moisture contents of these *Eichhornia crassipes* samples were much lower than the fresh samples reported by Little, (1979) and Okoye *et al. (*2002). Moisture content is an indication of the durability as well as the shelf life of food, and high moisture content in foods has been shown to encourage microbial growth (Temple *et al*., 1996). The low moisture content of these samples suggests that they are not liable to bacterial spoilage during storage (Table 1). Carbohydrates provide readily metabolized source of energy which is essential for the maintenance of plant and animal life. The carbohydrate content of the leaf (17.86 ± 0.01%) was

Table 1. Composition of formulated diets (g) fed different groups of rats for (g/kg) 28 days.

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Corn starch	-	650	650	650	750
Sucrose	-	50	50	50	50
Vitamin/mineral mixture	-	50	50	50	50
Palm oil	-	100	100	100	100
Non nutritive cellulose	-	50	50	50	50
E. crassipes leaf	-	380.97			
*E. crassipes*stem	-	-	835.93	-	-
*E. crassipes*root	-	-	-	1021.99	-
Nutrend	1000	-	-	-	-
Total	1000	1280.97	1735.93	1981.99	1000

Diet 1 – Reference (control), Diet 2 – Eichhornia crassipes leaf, Diet 3 - Eichhorniacrassipes stem, Diet 4 – Eichhornia crassipes root, Diet 5 - Basal diet.

Table 2. Proximate composition of the leaf, stem and root of *Eichhornia crassipes*.

% Composition	Leaf	Stem	Root
Moisture	11.70 ± 0.35^{a}	3.00 ± 0.61^{b}	5.00 ± 0.40^{c}
Carbohydrate	17.86 ± 0.1^{a}	11.75 ± 0.59^{b}	3.67 ± 0.17^{c}
Protein	21.44 ± 1.15^{a}	9.04 ± 0.51^{b}	6.86 ± 0.67^{c}
Lipid	0.23 ± 0.10^{ab}	0.22 ± 0.08^{ab}	0.60 ± 0.09^{c}
Fibre	37.66 ± 1.16^{a}	57.99 ± 1.14^{a}	24.47 ± 0.90^{c}
Ash	11.11 ± 0.37^{a}	18.00 ± 1.21^{b}	59.27 ± 0.35^{c}
Energy value (Kcal/100g)	159.27^{a}	85.14^{b}	47.52^{c}

Values are means ± standard deviation of triplicate determinations. Values in the same row bearing different superscripts are significantly different at the 0.05 level.

higher than that of the stem (11.75 ± 0.59%) and root (3.67±0.17). These values are lower than that of the maize and millet used in live stock feeding. *Eichhornia crassipes* feeds should be supplemented with feeds rich in energy when animal performance is expected, as in the case of growing animals (Heuze *et al*., 2012). The percentage protein ranged from 6.86 ± 0.67% (root) to 21.44 ± 1.15% (leaf) (Table 2). The crude protein obtained in this study for *Eichhornia crassipes* samples is similar to those of Okoye *et al*., (2002) and Nguyen, (2006). The leaf of *Eicchornia crassipes* is rich and higher in protein than that of corn grit i.e. maize (Boyd, 1974), guinea corn and palm kernel cake (Eyo, 1994) and lower than that of the duck weed (Mbagwu and Adeniji, 1988). Crude fat content was highest in the root (0.60±0.09%) and lowest in the stem (0.22±0.08%). There is no difference between the crude fat content of the leaf and stem. These values are lower than that of Okoye *et al*., (2002). Fibre content is a significant component of the diet, which is commonly used as an index of value in poultry and feeding stock's feeds (Eze and Ibeh, 2005). The crude fibre content was highest in stem (57.99±1.14%) and lowest in the root (24.47±0.90%). These values were higher than those reported by Nguyen, (2006). Good fibre content increases faecal bulk and lowers the time that waste materials spend in the gastro intestinal tract. The root of *Eichhornia crassipes* had the highest ash content of 59.27±0.35%, which was significantly (p<0.05) different from the leaf and stem contents. This high value obtained for the root might be attributed to its direct contact and accumulation of absorption nutrients of the growing media. The ash content is essentially a measure of the mineral content of a food sample, the high ash content of the *Eichhornia crassipes* root is indicative of the fact that the root contains more minerals than the leaf and stem. The energy value of *Eichhornia crassipes* samples ranged from 47.52kcal/100g (root) to 159.27kcal/100g (leaf). These values indicate that *Eichhornia crassipes* may be used as sole forage without concentrate supplements only for short maintenance periods to avoid weight loss, severe malnutrition and possible death (Abdelhamid and Gabr, 1991). The vitamin profile of the leaf, stem and root of *Eichhornia crassipes* studied shows that all samples contain some amounts of water and fat soluble vitamins. Vitamin C was the most abundant vitamin while vitamin D was the least abundant for all samples (Table 3). The vitamin A content of all samples were higher than those of the corn, sorghum and wheat grain used in feed formulation as reported by McDowell (2000).

The vitamin E and K contents of the leaf were the highest among the three samples. The values of vitamins

Table 3. Vitamin profile of the leaf, stem and root of *Eichhorniacrassipes*

Vitamin (mg/100g)	Leaf	Stem	Root
A	1.80 ± 0.01^{a}	1.23 ± 0.01^{b}	1.56 ± 0.00^{c}
B_1	$7.38 \times 10^{-1} \pm 0.00^{abc}$	$4.18 \times 10^{-1} \pm 0.00^{abc}$	$4.08 \times 10^{-1} \pm 0.00^{abc}$
B_2	$3.76 \times 10^{-1} \pm 0.00^{abc}$	$2.31 \times 10^{-1} \pm 0.00^{abc}$	$1.55 \times 10^{-1} \pm 0.00^{abc}$
B_3	$2.84 \times 10^{-1} \pm 0.00^{abc}$	$4.82 \times 10^{-2} \pm 0.00^{abc}$	$9.61 \times 10^{-2} \pm 0.00^{abc}$
B_5	$1.36 \times 10^{-2} \pm 0.00^{abc}$	$6.33 \times 10^{-3} \pm 0.00^{abc}$	$1.27 \times 10^{-2} \pm 0.00^{abc}$
B_6	$3.53 \times 10^{-2} \pm 0.00^{abc}$	$1.11 \times 10^{-2} \pm 0.00^{abc}$	$1.76 \times 10^{-2} \pm 0.00^{abc}$
B_9	$5.62 \times 10^{-2} \pm 0.00^{abc}$	$4.27 \times 10^{-2} \pm 0.00^{abc}$	$3.13 \times 10^{-2} \pm 0.00^{abc}$
C	204.80 ± 0.00^{a}	216.61 ± 0.01^{b}	207.66 ± 0.00^{c}
D	$6.18 \times 10^{-6} \pm 0.00^{ac}$	$3.63 \times 10^{-6} \pm 0.00^{b}$	$6.28 \times 10^{-6} \pm 0.00^{ac}$
E	18.22 ± 0.00^{a}	5.33 ± 0.00^{b}	9.04 ± 0.00^{c}
K	$3.08 \times 10^{-4} \pm 0.00^{abc}$	$1.34 \times 10^{-4} \pm 0.00^{abc}$	$1.28 \times 10^{-4} \pm 0.00^{abc}$
Total	226.32 ± 0.00^{ab}	223.93 ± 0.00^{ab}	218.97 ± 0.00^{bc}

Values are means ± standard deviation of triplicate determinations. Values in the same row bearing different superscripts are significantly different at the 0.05 level.

Table 4. Amino acid profile of the leaf, stem and root of *Eichhorniacrassipes.*

Amino acid (mg/100g)	Leaf	Stem	Root
Glycine	4.67 ± 0.00^{ac}	6.07 ± 0.00^{b}	4.84 ± 0.00^{ab}
Alanine	6.98 ± 0.00^{abc}	6.77 ± 0.00^{abc}	6.82 ± 0.00^{abc}
Serine	4.20 ± 0.00^{abc}	4.25 ± 0.00^{abc}	3.50 ± 0.00^{abc}
Proline	2.68 ± 0.00^{abc}	2.40 ± 0.00^{b}	2.57 ± 0.01^{c}
Valine	3.36 ± 0.00^{abc}	3.09 ± 0.00^{abc}	2.95 ± 0.00^{abc}
Threonine	4.38 ± 0.00^{a}	3.22 ± 0.00^{b}	3.52 ± 0.00^{c}
Isoleucine	3.06 ± 0.00^{a}	4.58 ± 0.01^{b}	2.94 ± 0.00^{c}
Leucine	7.02 ± 0.00^{abc}	8.08 ± 0.00^{abc}	8.69 ± 0.00^{abc}
Asparagine	8.40 ± 0.01^{a}	7.59 ± 0.01^{b}	8.19 ± 0.00^{c}
Lysine	7.73 ± 0.00^{abc}	5.21 ± 0.00^{bc}	6.06 ± 0.00^{abc}
Methionine	2.09 ± 0.01^{a}	1.33 ± 0.00^{bc}	1.47 ± 0.00^{bc}
Glutamine	15.13 ± 0.01^{ac}	11.95 ± 0.00^{b}	15.12 ± 0.00^{bc}
Phenylalanine	4.26 ± 0.00^{a}	4.53 ± 0.00^{b}	3.91 ± 0.01^{c}
Histidine	2.93 ± 0.01^{a}	2.01 ± 0.00^{b}	3.01 ± 0.01^{c}
Arginine	5.25 ± 0.00^{a}	8.06 ± 0.00^{b}	4.40 ± 0.00^{c}
Tyrosine	2.20 ± 0.01^{a}	2.33 ± 0.01^{b}	2.10 ± 0.01^{c}
Cysteine	1.78 ± 0.00^{a}	2.31 ± 0.01^{b}	2.18 ± 0.01^{c}
Total	86.12 ± 0.00^{abc}	84.36 ± 0.00^{abc}	82.28 ± 0.00^{abc}

Values are means ± standard deviation of triplicate determinations. Values in the same row bearing different superscripts are significantly different at the 0.05 level.

A, C and E were all significantly (p<0.05) different in all the samples. Vitamins B_1, B_2, B_3, B_4, B_6 and B_9 contents were very small in all the samples. The vitamin content of *Eichhornia crassipes* may not be suitable for growing animals but ruminants (finishing) whose demand for vitamins A and E requirements are not much can be fed with the plant. Vitamin D content of *Eichhornia crassipes* is small, but the animals can be kept under sunlight for vitamin D activation from their skin by the ultraviolet rays. The other vitamins such as vitamin B complex and K can be provided in the animals (ruminants) by the ruminal microbial synthesis (McDowell, 2000). The leaf, stem and root of *Eichhornia crassipes* had essential and non essential amino acids in the amino acid profile (Table 4). There were variations in the contents of the essential and non essential amino acids in the samples. Glutamic acid was the highest in content, followed by aspartic acid and the least being cysteine in the leaf, stem and root of *Eichhornia crassipes* for non-essential amino acids. Histidine was the most abundant amino acid while methionine was the least in all samples for the essential amino acids. Threonine, isoleucine, methionine, phenylalanine, hisitidine and arginine were all significantly (p<0.05) different in all the samples. Lysine which is a limiting amino acid in most cereals and legumes (Olusanya, 2008) was higher than most of the

essential amino acid. Histidine and arginine which are important amino acids for infant growth were also present and phenyl alanine value in the leaf is similar to the values of the leaves of browse plants that can be used in non-conventional feeds as reported by Amata and Lebari, (2012).

Conclusion

The findings of this study have shown the nutritional potentials of the plant, *Eichhorniacrassipes*. The leaf contains an appreciable amount of protein, an important macronutrient in animal nutrition.

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