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Chemical and Nutritional Composition of Water Lettuce (*Pistia Stratiotes*) Plant from Different Sources in Cape Coast, Ghana – A Preliminary Study

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Abstract

Water lettuce is found growing in several bodies of water in Ghana, reaching pest levels in certain locations. They often pose negative effects on other aquatic life and water quality. Attempts at eradication have proven difficult and expensive although utilization as animal feed has been reported elsewhere. This study was undertaken to assess the nutritional and chemical compositions of water lettuce plants obtained from different water bodies in Cape Coast: Fresh Water (Kakum River), Saline Water (Fosu Lagoon) and Waste Water (Residential areas). The water lettuce samples were harvested on the same days from the various water bodies from August to December, 2013, using seine nets. Proximate composition of the whole plant, and its parts were determined, as well as the heavy metal content of the whole plant. In addition, samples of water from the various water bodies were analysed for heavy metal content. Data obtained from the study were subjected to analysis of variance (ANOVA) using GenStat statistical software (fourth edition). Results from the study indicated that the heavy metal contents of the plants and the water bodies from which they were harvested were significantly ($P < 0.05$) lower than the maximum permissible levels set by the European Commission. The crude protein contents were higher in the leaves of the plants than in the corresponding stems and roots. The leaves had higher crude protein and fats, but had lower fibre content than the others parts of the plant. Findings from the study indicate that water lettuce has potential for use as livestock feed. It is recommended that preliminary feeding trials with various species of livestock in Ghana be undertaken to determine its effects on growth and carcass parameters.

Keywords: Heavy metals, water lettuce, saline water, waste water, proximate composition

Introduction

Aquatic plants are plants that grow either partly or wholly in water, and can be rooted in sediments or are free floating on the water surface (Wersal and Madsen, 2012). Charudattan (2001) and Holm *et al.* (1977) listed water lettuce (*Pistia stratiotes*) as one of the world's most invasive and difficult-to-control plants.

Water lettuce (*Pistia stratiotes*) is an invasive aquatic plant noted for its explosive growth potential and high ability to grow from few plants to cover large areas of water surface within a short period (Groth *et al.*, 1996; Barrett, 1989). By virtue of its growth habit, the plant is capable of blocking navigation channels, irrigation ditches and water intake pipes. They can also impede wildlife resources, constitute a hazard to life and reduce aesthetic and recreational value of water bodies. These adversely affect tourism potential and real estate value of water bodies (Catling and Dobson, 1985). In some countries, the plants have been reported to increase breeding habitat for mosquitoes (Eiswerth *et al.*, 2000). Control measures adopted to minimize the negative effects of this plant on the society have been reported to be very expensive. In the United States alone, reports indicate that controlling aquatic weeds costs up to \$137 billion per year (Pimentel *et al.*, 2000).

In Ghana, water lettuce invasion is threatening the survival of most water bodies, making fishing activities very difficult for many fisher folk. Studies indicate that the plant grows rapidly in several water bodies, including the Volta Lake, River Afram and the Weija Lake (Ewer, 1996). Unlike other aquatic plants, the growth of water lettuce is not restricted to fresh water, but is reported to demonstrate a remarkable degree of tolerance to salinity (Gerlach, 1996). In the Central Region of Ghana, water lettuce grows rapidly in the "Fosu" Lagoon (saline), "Kakum" river (fresh water) and in several drainage canals in the Cape Coast Metropolis. Attempts at controlling this plant over the years yielded little positive results. A potential use of this plant is as an ingredient in formulating livestock feed. This has been undertaken in a few places around the world with varying results (Van Soest, 1982). It is believed that finding an economic use for this plant might serve as a better control measure.

It has been reported in several publications that water lettuce is effective in taking up of heavy and even toxic metals present in saline and waste water (Gupta *et al.*, 2012)

Finding ways to effectively utilize water lettuce as livestock feed in Ghana will help unearth a potentially new and cheaper source of nutrients in place of some of the more conventional sources. This will assist work by research scientists to minimize the problems of inadequate feed supply to livestock in Ghana.

This study therefore sought to assess the nutritional and chemical composition of water lettuce plants harvested from different water bodies in Cape Coast, to determine their suitability for use as livestock feed.

MATERIAL AND METHODS

Study Area

Water lettuce samples were harvested from three (3) different water bodies in Cape Coast; Saline Water (Fosu Lagoon), Fresh Water (Kakum River) and Waste Water (Residential areas in Cape Coast). Different water bodies were selected to determine whether the growth medium has any effect on the chemical and nutritional composition of the plant. All analyses were conducted in the Laboratories of the School of Agriculture, University of Cape Coast and the Faculty of Agriculture, University for Development Studies, Tamale.

Sampling and Preparation of Samples for Laboratory Analysis

Water lettuce samples were harvested from the water bodies with seine nets, over a period of four months (from August to December, 2013). The samples were bagged in transparent polythene bags. At the laboratory, the water lettuce from each treatment was washed, and some were apportioned into leaves, stems and roots. The samples were stored in a refrigerator at a temperature of -1°C for proximate and heavy metal content analyses.

Proximate Analyses of Samples

The crude protein, dry matter, ether extract, fibre and ash contents of the samples were determined according to the methods described by the Association of Official Analytical Chemists (AOAC, 1999).

Analyses of Heavy Metal Composition of Samples

The total Lead (Pb), Potassium (K), Sodium (Na), Zinc (Zn), Iron (Fe), Copper (Cu), Manganese (Mn) and Cadmium (Cd) residues in the water lettuce plant were determined in this study. Potassium and Sodium levels were determined using Flame Photometer whilst Iron, Copper and Zinc contents were

determined using Atomic Absorption Spectrophotometer (AAS). The procedures outlined by the Association of Official Analytical Chemists (AOAC, 1990) were followed in the analyses.

Data Analysis

All laboratory analyses were conducted in triplicate. The data generated was subjected to analysis of variance (ANOVA) using GenStat statistical software (fourth edition) and where significant differences occurred, the means were compared at 5% level of significance. Means for heavy metal concentrations were compared with the European Commission's Standards for Maximum Permissible Levels (MPLs) (ECR, 2006).

Plant Part	Crude protein	Fibre	Ether extract	Ash
	Mean	Mean	Mean	Mean
Leaves	18.61	12.18	4.12	10.34
Stem	14.99	19.37	2.68	13.03
Roots	12.34	12.44	1.43	16.12
Whole	14.03	12.7	2.71	11.22
plant	14.03	12.7	2.71	11.22
Leaves	18.61	12.18	4.12	10.34
Stem	14.99	19.37	2.68	13.03
Roots	12.34	12.44	1.43	16.12
Whole	14.03	12.7	2.71	11.22
plant	14.03	12.7	2.71	11.22

SED = Standard Error of Difference; Means in the same row with different letters are significantly different; ** = significant (p < 0.01); *** = highly significant (p < 0.001).

The proximate composition of the plants is presented in Table 1. The dry matter content of the fresh water lettuce plants were quite low, ranging between 0.04 and 1.76%. The dry matter content did not vary significantly (p > 0.05) in whole plants from different water bodies but appears to be much higher in the

Results and Discussion

Table 1: Proximate Composition of the Water Lettuce Plants from Various Water Bodies

Composition (%)	Section	SW	FW	WW	SED	Sig
Dry Matter	Leaves	6.81	6.84	6.87	0.41	NS
	Stem	13.76	12.15	12.79	0.36	NS
	Roots	6.94	7.33	6.64	0.34	NS
	Whole plant	7.12	7.60	7.31	0.41	NS
Crude protein	Leaves	30.34 ^a	26.16 ^b	22.31 ^c	0.69	***
	Stem	18.62	18.99	18.01	0.57	NS
	Roots	16.10 ^b	18.33 ^a	15.03 ^b	0.70	**
	Whole plant	21.03 ^a	19.03 ^a	17.36 ^b	0.86	***
Fibre	Leaves	15.18	15.10	15.96	0.39	NS
	Stem	19.27	20.20	19.01	0.61	NS
	Roots	15.68	15.60	15.88	0.45	NS
	Whole plant	15.31	15.30	15.53	0.56	NS
Ether extract	Leaves	4.35	4.68	4.27	0.23	NS
	Stem	2.68	2.45	2.70	0.13	NS
	Roots	1.53	1.45	1.41	0.09	NS
	Whole plant	2.71	2.75	2.27	0.19	NS
Ash	Leaves	10.34	10.28	10.83	0.20	NS
	Stem	13.03	13.63	13.22	0.80	NS
	Roots	16.15	16.99	16.40	1.15	NS
	Whole plant	11.55	11.43	11.36	1.08	NS

SED=Standard Error of Difference; Means in the same row with different letter superscripts are significantly different; NS= not significantly different($P>0.05$); *** = Significant ($P<0.001$); ** = Significant ($P<0.01$); SW= saline water; FW= fresh water; WW= waste water

The proximate composition of the plants is indicated in Table 1. The dry matter content of the fresh water lettuce plants were quite low, ranging between 6.64 and 13.76 %. The dry matter content did not vary significantly ($p>0.05$) in whole plants from different water bodies; but appears to be much higher in the

stems than in the leaves. The findings are in line with those of Banerjee and Mata (1990), who reported that moisture levels in water lettuce could be as high as 94%. Ayoade *et al.* (1982) also reported that the stems of water lettuce plants are relatively harder and hence have higher dry matter content than the leaves. The crude protein content ranged between 15.01 and 30.34%, with leaves having much higher CP content than the stems and roots. In addition, the leaves of the plants harvested from the lagoon had significantly ($p < 0.001$) higher CP content than those from the fresh water and waste water. Banerjee and Mata (1990) recorded crude protein value of 25.5% in the leaves of water lettuce plants. It was observed during the harvesting period that the lagoon had larger surface area than the fresh water and the waste water bodies. This obviously affected nutrient availability as there would be limited competition among plants having larger growth medium than those with smaller growth medium. The fibre content ranged between 15.10 and 20.20 %. The stems had higher fibre content than the other parts of the plant. It was observed that the growth medium had no effect on the fibre content of the plant. The findings from the current study were quite similar to earlier findings by Rodriguez *et al.* (2000) and Johnson *et al.* (2003), which indicated that water lettuce plants have fibre content of about 19.13%.

The ether extract (fat) content ranged between 1.41 and 4.68%. The leaves appeared to have higher fat content than the roots. The growth medium however, did not have significant ($p > 0.05$) effect on the fat content of the plant. The findings from the current study are again similar to earlier findings of Boyd (1986).

The ash content varied between 10.34 and 16.99%. The leaves had lower ash content than the roots and stems. Higher ash content in plants is usually an indication of higher mineral levels, but could also be influenced by contamination with soil. The latter is possible due to the harvesting method adopted in this study.

Table 2: Heavy Metal Content of the Water Lettuce Plants from Various Sources

Heavy metal	SW	FW	WW	MPL(mg/kg)	SEM (+/-)
Copper	9.75×10^{-4b}	4.60×10^{-4b}	2.06×10^{-3a}	20	1.02×10^{-4}
Zinc	1.46×10^{-2a}	7.16×10^{-3b}	6.43×10^{-2a}	50	3.52×10^{-4}
Potassium	1.57	1.06	1.65	10	0.07
Sodium	0.82	0.75	0.85	100	0.05
Iron	2.25 ^a	1.06 ^b	2.14 ^a	50	0.11
Cadmium	ND	ND	ND	0.05	-
Lead	ND	ND	ND	0.10	-
Mercury	ND	ND	ND	0.10	-

Means in the same row with similar superscripts are not significantly different ($p>0.05$);

SEM= Standard Error of Mean; MPL= European Commission's Maximum Permissible

Limit of product acceptability, ND= not detected; SW= saline water; FW= fresh water;

WW= waste water.

The levels of some heavy metals determined in the water lettuce plants are shown in Table 2. Cadmium, Lead and Mercury were not detected in the water lettuce samples, indicating that these were either not present in the samples or the levels were insignificant to be detected. Total Copper, Zinc, Potassium, Sodium and Iron were however detected in the samples (Table 2). The levels of Copper, Zinc and Iron in Water lettuce plants harvested from the waste water (WW) were significantly ($p<0.05$) higher than in those from the fresh water (FW) and the Lagoon water (SW). This probably indicates that the waste water was more polluted than the lagoon and the fresh water. The levels of these heavy metals were however lower than the maximum permissible levels. The Sodium and Potassium levels were not significantly ($p>0.05$) different among the plants from different water bodies. Similarly, the levels of Sodium and Potassium were also lower than their corresponding maximum permissible levels recommended by the European Commission (ECR, 2006).

Table 3: Heavy Metal Contents of the Water from which the Plants were Harvested

Heavy Metal	SW	FW	WW	MPL(mg/kg)	SEM (+/-)
Copper	3.0×10^{-2}	2.0×10^{-2}	3.0×10^{-2}	20.0	1.0×10^{-3}
Zinc	2.1×10^{-3}	2.3×10^{-3}	3.0×10^{-2}	50.0	1.1×10^{-4}
Potassium	15.00 ^a	12.00 ^b	17.00 ^a	10.0	1.03
Sodium	18.28 ^b	19.36 ^b	22.58 ^a	100.0	1.42
Iron	1.57	1.46	1.72	50.0	0.96
Cadmium	ND	ND	ND	0.05	-
Lead	ND	ND	ND	0.10	-
Mercury	ND	ND	ND	0.10	-

Means in the same row with similar superscripts are not significantly different

($p>0.05$); SEM= Standard Error of Mean; MPL= European Commission's

Maximum Permissible Limit of product acceptability, ND= not detected; SW=

saline water; FW= fresh water; WW= waste water.

The heavy metal content of the water from which the plants were harvested are presented in Table 3. Similar to the observations in Table 2, Cadmium, Lead and Mercury were not detected in the water from which the plants were harvested. The Copper and Zinc levels were lower than their respective maximum permissible levels (ECR, 2006). In addition, they were not significantly different in the various water sources. The Potassium and Sodium levels were significantly higher in the waste water than the saline and fresh waters. The levels of these metals were however lower than their respective Maximum permissible levels (ECR, 2006).

Conclusions and Recommendations

The moisture content of water lettuce plants was high, implying that one has to harvest a lot of it to be able to get a substantial amount of dry matter for commercial feed supply purposes. This practise will ultimately help control the plant in the water bodies. The crude protein content was quite high, making it potentially a suitable ingredient for livestock feed formulation. The heavy metal levels in the plants and the water from which they were obtained were significantly lower than their respective maximum permissible levels by the European Commission, hence will pose no threats when they are used as livestock feed as at present. It is however important to continuously monitor changes in these levels over time, if being used as animal feed.

Further studies need to be conducted to determine the true protein, amino acids, minerals and vitamin contents of the plant to ascertain its potential nutritional importance to livestock. Preliminary feeding trials with various species of farm animals in Ghana could be undertaken and carcasses analysed for any residual effect in meat. Ways to devise simple drying procedures or ensiling product for animal feed.

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