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Nutritional Composition and Digestibility of Water Hyacinth and Water Pennywort

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ABSTRACT

Water hyacinth *(Eichhornia crassipes)* and water pennywort *(Hydrocotyle ranunculoides)* collected from waste treating ponds receiving wastewater from chicken houses were evaluated for the feasibility of using as livestock feeds. The averaging nutritive contents for crude protein, crude fat, acid detergent fiber and ash were 18%, 1%, 33% and 17% for water hyacinth and 24%, 2%, 29% and 18% for water pennywort, respectively. The amino acids contents of these aquatic plants were reported. *In vitro* dry matter digestibility for water hyacinth and water pennywort by using enterogastric juice of a cattle as digestive fluid were 48% and 69%, respectively. Except for high moisture contents, the nutritive values and dry matter digestibility of water hyacinth and water pennywort were comparable to alfalfa for using as feed for livestocks.

Key words : water hyacinth, water pennyworth.

INTRODUCTION

Aquatic plants have been utilized for improving water quality and facilitating nutrient recovery from waters in many parts of the world. Many aquatic plants can effectively use solar energy to fix carbon while absorbing nutrients and other chemicals from water to produce more plant biomass. If the plants were removed for nutrient abatement purpose, they could probably be dried and used as a feedstuff. The food value would offset the cost of removal to some extent.

There have been numerous attempts to utilize aquatic plants for animal feeds in Southeast Asia. Aquatic plants such as water hyacinth, duckweed and hydrilla have potential as animal feed (Boyd 1968, Culley and Epps, 1973). Cattle have grazed floating water hyacinths when land forages were limited (Davies, 1959). Water pennywort after removing from wastewater treating was considered potential as animal feed.

Aquatic plants differ appreciably in chemical composition and, therefore, vary in nutritional value. Many techniques are used to estimate the nutritive quality of animal foods. The most reliable data are obtained from feeding trials and growth studies; however, such experiments are time consuming (Pollisive and Boyd ,1972) the nutritional content and digestibility determination are useful, simple, rapid techniques for estimating the food value of aquatic plants (Abdella *et al.*, 1987).

Little information on the nutritional content and digestibility are available for water hyacinth and water pennywort (*Hydrocotyle ranunculoides*). The objective of this study, therefore, was to evaluate proximate nutritional composition, amino acid profile, and digestibility of dried water hyacinth and water pennywort grown in effluent from chicken house and to compare these values to those of forage plants used in cattle feed.

MATERIALS AND METHODS

Whole water hyacinth and water pennywort, grown in poultry waste lagoon receiving wastewater from chicken house at Auburn University, U.S.A. were used for treating wastewater before discharging. During May to September of 1990, samples of these plants were monthly collected for an analysis of nutrient compositions and *in vitro* dry matter digestibility. The plants were rinsed with tap water, cut into small pieces and heated in a forced air oven for 24 h at 100°

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C for dry matter determination. Dry samples were ground into a fine meal with a Wiley mill (1 mm mesh screen) and stored in sealed plastic bags until analysed.

Crude protein, lipid and ash content of the dried plant was analysed by macro-Kjeldahl, ether extraction and muffle furnace combustion respectively, as described by Lovell (1981). Forage fiber content was analysed with the acid detergent fiber procedure described by Goering and Van Soest (1970). Samples of water hyacinth and water pennywort collected in July were used for determination of *in vitro* dry matter digestibility and amino acids. *In vitro* dry matter digestibility were determined according to the procedure of Tilley and Terry (1963) using enterogastric juice of a cattle as digestive fluid. Dry matter digestibility was also analysed in alfalfa and bermuda grass obtained from the Animal Science Department of Auburn University for comparison to those of water hyacinth and water pennywort. Amino acid contents of water hyacinth and water pennywort were analysed by a commercial laboratory (Woodland-Tenant Laboratories, Inc., Memphis, Tennessee) using amino acid analyzer. Amino acid profiles of these plants were then compared with those values of the conventional roughage and alfalfa obtained from Church and Pond (1978).

RESULTS AND DISCUSSION

Nutritional composition of water hyacinth

Mean crude protein of water hyacinth ranged from 12 to 19% (Figure 1). These values were consistent with those reported by Boyd (1968), Reddy and Mohanrao (1979), and Wolverton and McDonald (1981). Wide ranges in crude protein have resulted from age variability of water hyacinths (NAS, 1976). As water hyacinth aged, protein content decreased. The amino acids profile of water hyacinth were low in tryptophan and tyrosine in comparison to alfalfa. However the former was higher in glycine, isoleucine and histidine than the latter. The other amino acids of these two plants were not much different (Table 1).

Mean crude fat in water hyacinths ranged from 0.7 to 1.7% (Figure 1). Gollamudi *et al.* (1984) reported that fat in water hyacinths was primarily found in leaves (14.9%), whereas roots and stalk contained 1.6 and 0.9% fat, respectively. In this study roots and stalks represented a major portion of the sample analysed. Hence, the overall fat content observed in this study was relatively low.

Mean acid detergent fiber (ADF), or lignocellulose content, of water hyacinths ranged from 33 to 37%. Fiber increased as the plants aged (Figure 1). Wolverton and McDonald (1981) suggested that the higher content of fiber in older hyacinths was a result of increased cellulose content.

Mean ash represents inorganic matter which mainly includes plant minerals. In this study ash varied from 15 to 18% (Figure 1), high content of ash in water hyacinth was probably due to accumulation of minerals absorbed from the wastewater that plant grown. Boyd (1968) found that floating aquatic plants contained very large quantities of ash, similar to levels in submerged plants. Ash content also declined as plants aged, because cellulose content increased.

Table 1 Amino acid composition (percentage of crude protein) of water hyacinth and water pennywort grown in poultry wastewater lagoon effluent, compared to soybean meal.

Amino acid	Water hyacinth[1]	Water pennywort[2]	Alfalfa[3]
Tryptophan	10.9	0.59	2.50
Aspartic acid	18.59	16.07	-
Threonine	4.85	2.38	4.16
Serine	5.51	2.48	-
Hydroxyproline	0.06	0.04	-
Glutamic acid	29.92	6.81	-
Proline	4.97	2.73	-
Glycine	6.48	2.78	4.72
Alanine	10.05	3.20	-
Cystine	1.09	0.50	0.94
Valine	5.68	2.82	5.24
Methionine	1.64	0.72	1.39
Isoleucine	4.42	2.19	1.94
Leucine	8.12	4.19	7.20
Tyrosine	1.82	1.35	3.06
Phenylalanine	5.51	2.65	5.28
Hydroxylysine	0.06	0.04	-
Histidine	3.27	2.27	1.94
Lysine	5.21	2.61	4.19
Arginine	5.57	2.48	4.17

[1] Crude peotein (Percentage of dry matter) of water hyacinth = 16.51.

[2] Crude peotein (Percentage of dry matter) of water pennywort = 23.77.

[3] Crude peotein (Percentage of dry matter) of alfalfa = 18 (Church and Pond, 1978).

Table 2 Average nutritional composition of water hyacinth and water pennywort grown in poultry wastewater lagoon effluent relative to that of some conventional animal feedstuffs.

Plant	H_2O	Crude Protein	Fat	ADF	Ash	Rumen digestibility
Water hyacinth	95.0	17.8	1.1	33.4	16.8	47.9
Water pennywort	95.0	24.2	1.7	29.4	18.3	69.3
Alfalfa[1]	76.1	18.3	2.6	35.0	8.7	55.4
Bermuda grass[2]	63.5	13.5	3.4	34.5	7.8	56.7

[1] Alfalfa (*Medicago sativa*), fresh midbloom (NRC, 1984).
[2] Kentucky bermuda grass (*Poa pratensis*), average early and mature vegatative (NCR, 1984).

Nutritional composition of water pennywort

Mean crude protein content of water pennywort averaged 23 to 25% (Figure 2). Unlike water hyacinth, crude protein of water pennywort were not much varied with ages. Water pennywort was also higher in crude protein than water hyacinth and alfalfa (by comparison); however, the amino acid composition of water pennywort was usually lower than that in water hyacinth and alfalfa (Table 1). This might indicate that total nitrogen, which was used to estimate crude protein content of water pennywort, was higher in non-protein nitrogen compounds than those in water hyacinth.

Crude fat content of water pennywort (Figure 2) did not vary much from May to September (1.5-2.0%) with averaging of 1.75%. This value was higher than that of water hyacinth but lower than those of alfalfa and burmuda grass (Table 2).

Mean acid detergent fiber of water pennywort was highest (36%) in the first month of the experiment and seemed to vary little after that (Figure 2). It is uncommon for younger plants to have the highest fiber content; however, this was probably resulted from much of stalk of water pennywort made up a large portion of samples collected in May. In older plants, fiber ranged from 25 to 29%.

Mean ash values in water pennywort were highest in young plants (24%) and later dropped to levels of 16 to 18% (Figure 2). Stalks of water pennywort (major portion in first samples) apparently contained more minerals than the leaves.

Comparative nutritional value of water hyacinth and water pennywort to that of some conventional animal feedstuff

The major nutritional components of water hyacinths and water pennywort appear along with values for conventional livestock roughage in Table 2. On a dry weight basis, average crude protein of water hyacinth (17.8%) was similar to that of alfalfa but higher than that of Burmuda grass. Protein content of pennywort was highest among all plants in comparison.

However, protein quality of water pennywort was inferior to those of water hyacinth and alfalfa because water pennywort had poor amino acid profile. Therefore, water pennywort has less potential values as a protein source for animal feeds. Water hyacinth contained similar amount of methionine and lysine, the most two limiting amino acids in plants, to those of alfalfa. Water hyacinth, however, contained less tryptophan and tyrosine but contained more glycine and isoleucine than alfalfa. The amino acid profile of water hyacinth suggested that it could have potential at least comparable to alfalfa for use as animal feeds. However, availability of the amino acids in water hyacinth to nonruminant may be of concern because of the high fiber content. Also, high water content of water hyacinth made it too bulky for feeding to animals unless water content was removed.

Mean crude fat values in both water hyacinth (1.1%) and water pennywort (1.7%) were generally lower than those of other roughage plants (Table 2). Linn *et al.* (1975) showed that submerged and floating plants generally contained less fat than emergent plants.

Mean acid detergent fiber (ADF) was 33.4% in water hyacinth and 29.4% in water pennywort. These values are slightly lower than those of alfalfa and Bermuda grass. Water buoyancy probably replaces some of the need for structural materials in aquatic plants, resulting in lower fiber.

Mean ash content of water hyacinth (16.8%) and water pennywort (18.3%) were higher than found in roughage plants. Although some minerals are essential, excessive concentrations of ash decreases the amount of organic constituents per unit weight and lower nutritional value of the plants (Culley and Epps,1973; Pollisive and Boyd, 1972).

Water pennywort had a higher rumen digestibility than any other plants considered in Table 2. This is probably due to low ADF. Boyd (1968) and Van Soest and Wine (1967) found that cellulose and lignin in aquatic plant cell walls had an adverse effect on

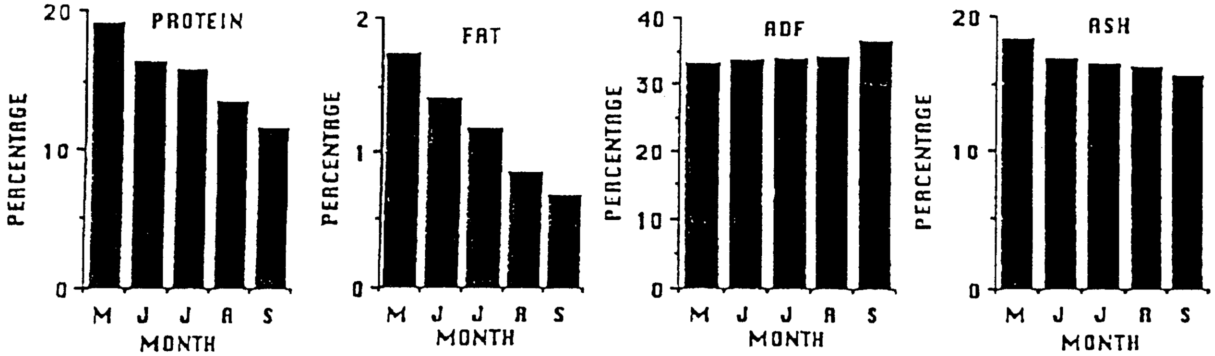

Figure 1 Mean protein, fat, and acid detergent fiber (ADF) and ash (dry wt. basis) at monthly intervals of dried water hyacinth grown in poultry wastewater lagoon effluent.

digestibility.

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