The Amino Acid Composition Of Water Hyacinth (*Eichhornia Crassipes*) And Its Value As A Protein Supplement

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As increased human population exerts pressure on our food production resources, and lands suitable for agriculture approach maximum utilization, species of land and water plants that are as present economically unimportant may become useful food sources. The water hyacinth which clogs Florida lakes and rivers has attributes which warrant consideration of the plant as a possible food source. Yount (1) reported that water hyacinth produce over 534 pounds per acre per day dry weight, which is one of the greatest yields of organic matter ever reported, including even intensive agricultural and sewage algae production. In addition, water hyacinth tend to produce pure stands and, according to Pirie (2), a floating plant is ideally adapted for mechanical harvesting.

The present study undertakes to examine water hyacinth as a possible food source for humans. Any developments here would have ramifications for other areas of the world, since water hyacinths flourish in southeast Asia, the Nile and the Congo (1). Water hyacinth have been reported to be palatable to fish (3), sheep (4), cattle (5), pigs (6) and humans (7). However, due to its high water content the crude product has a low nutrient concentration. The dry matter of the plant may be of nutritional value as a supplemental source of amino acids since the biological value of leaf protein has been reported to be about equal to that of milk (8). The present objective is to examine the amino acid content of water hyacinth to determine whether its protein could effectively supplement the nutritional deficiencies of grains. The amino acid determination can only serve as a guide to the nutritional value of water hyacinth protein. Quality of the protein should be ultimately assessed through animal feeding experiments.

MATERIALS AND METHODS

Water hyacinths were collected from Lake Alice on the University of Florida farm and analyses made on the leaves (dried at 70°C overnight) for moisture, nitrogen, ether extract, ash and crude fiber. Nitrogen and moisture were also determined on the whole plant. AOAC (9) procedures were used for the determinations.

Samples (dried at 60°C for 14 hrs.) were weighed on an analytical balance in the weight range 100 to 120 mg and hydrolyzed in 100 ml of 6 N glass distilled HCl under nitrogen. A series of hydrolyses was carried out for 10, 20, 30, 40, 50 and 70 hr in a 137°C oil bath to determine when maximum yield of the amino acids occurred. Maximum yield of some of the essential amino acids, which was used as a criterion, appeared to be reached at 40 hr. Therefore, the hydrolyses for amino acid composition were carried out for 40 hr, with 6 replications. The amino acid analyses were carried out with a Technicon Amino Acid Analyzer, using citrate buffers of the standard Technicon procedure. The chromatographic column was 0.6 cm in diameter x 125 cm in length packed ith C-2 Chrommobead resin, particle diameter 13 ± 0.5 micron.

Samples were hydrolyzed; HCl was evaporated from each sample hydrolyzate, and the residue taken up in 10 ml of 0.1 N glass distilled HCl and filtered. A sample containing 0.2 ml of the filtrate, 0.1 ml norleucine, 0.1 ml 65% sucrose and 0.1 ml 0.1 N HCl was injected on the column. The chromatographic procedure took 11.5 hr plus regeneration time of the column. The resin was regenerated by pumping 0.2 N NaOH through it for 30 min followed by pH 3.1 buffer for 2.5 hr. Column temperature was 52°C during the first 2.5 hr of determination and 60°C during the last 9 hr. The buffer gradient system in the 9 chambered Autograd was chamber 1, pH 2.75 (containing 10% methanol); 2, 15 ml pH 2.75 + 25 ml pH 2.875; 3, pH 2.875; 4 and 5, pH 3.80; 6, 20 ml pH 3.80 + 20 ml pH 6.10 and 7, 8, and 9, pH 6.10. All chambers contained 40 ml. Norleucine was used as an internal standard and the areas under the chromatographic peaks were evaluated using a Technicon Integrator-Calculator.

RESULTS

The gross compositional analyses of water hyacinth leaves and whole plants are shown in Table 1.

The amino acid analysis of the acid hydrolyzates, given in Table 2, revealed the following amino acids: methionine, cystine, phenylalanine, tyrosine, threonine, lysine, leucine, isoleucine, valine, arginine, histidine, glycine, alanine, serine, aspartic acid, glutamic acid, and proline. All amino acids essential in the diet of humans were present except tryptophan, which was destroyed by the acid hydrolysis. The essential amino acids occurring from highest to lowest amounts were as follows: leucine, lycine, phenylalanine, threonine, isoleucine, methionine, and valine. The sum of the average of the seventeen amino acids recovered from six replicas of 40 hr hydrolyzates represents 92.3% of the total protein in the samples.

A comparison of the amounts of essential amino acids of water hyacinth with those of the F.A.O. reference (10), leaf protein concentrate (11), corn (12) and milk (10), is shown in Table 3.

TABLE 1. GROSS COMPOSITION OF WATER HYACINTH.[1]

	Dry Matter	Ash	N	Crude Protein	Crude Fiber	Ether Extract	N Free Extract
	%	%	%	%	%	%	%
Leaves	15.8	14.7	1.7	10.7	17.0	2.7	54.7
Whole Plants	8.9	......	1.5	9.6	......	......	......

[1]Dry weight basis

TABLE 2. Essential and Nonessential Amino Acids Yielded by the 40 Hr. Hydrolysis of 100 g of Water Hyacinth Protein Calculated at 16 g N/100 g Crude Protein.

	g		g
Methionine	0.73	Arginine	2.98
Cystine	11.60	Histidine	1.90
Phenylalanine	4.72	Glycine	5.14
Tyrosine	2.98	Alanine	5.59
Threonine	4.32	Serine	3.85
Lysine	5.34	Aspartic Acid	17.37
Isoleucine	4.32	Glutamic Acid	9.29
Valine	0.27	Proline	4.73
Leucine	7.20		

DISCUSSION

In the work being presented, amino acid composition of water hyacinth has been determined on plants which contained 9.6% protein, an amount consistent with the report of Yount (1) that the protein content of water hyacinth varies from 7.4 to 18.1% (N x 6.25) on dry weight basis. The higher protein levels were found in June and July with lower levels in May, August and September. Information is not available as to whether the variation in nitrogen is due to a variation in protein content or in free amino acids. Young plants, although they are higher in protein than mature plants, produce a proportionally smaller yield on a per acre basis (13).

The recovery of amino acids from the 40 hr hydrolyzates accounted for 92.3% of the total protein, indicating either incomplete hydrolysis or destruction of other amino acids in addition to tryptophan.

A point of interest is whether the amino acids of water hyacinth could serve as a supplemental source to improve the nutritional quality of grain proteins. Lysine and tryptophan are the first two limiting amino acids in grains, therefore interest centers on the concentration of these two amino acids in water hyacinth. Since any tryptophan present would be destroyed by the acid hydrolysis, only lysine can be considered at present.

The amounts of essential amino acids in water hyacinth can be compared to the F.A.O. reference pattern (10), leaf protein (11), corn (12), and milk (10) (Table 3). Water hyacinth protein shows deficient levels in only 2 of the essential amino acids, valine and methionine, as compared to the F.A.O. reference pattern. A diet containing an adequate protein level (1 g per kg body weight, NRC) will be balanced in lysine if it contains 4.2 g of that amino acid per 100 g of protein (g %). Corn is deficient in lysine, containing only 0.8 g %. However, water hyacinth contain 5.34 g % of lysine, while milk contains 7.8 g %. It is evident that water hyacinth could serve to improve the lysine content of a corn diet. Leaf protein which contains 6.3 g of lysine has been reported to be an effective supplement for barley in pig rations (14). Then, present evidence indicates that water hyacinth could be used to improve the lysine content of grains.

If subsequent work on trytophan content of water hyacinth reveals that this amino acid occurs in substantial amounts, the protein of hyacinth may be developed into useful dietary supplements for grain diets, especially in the underdeveloped countries. If a number of uses are found for the other constituents of water hyacinth so as to make processing economically feasible, the protein could be extracted. Such a protein concentrate could be used as an effective supplement to grains for animal or human consumption.

SUMMARY

The amino acid composition of water hyacinth was determined. The analysis revealed the following levels of essential amino acids in 100 g of crude protein: methionine 0.72 g, phenylalanine 4.72 g, threonine 4.32 g, lysine 5.34 g, isoleucine 4.32 g, valine 0.27 g and leucine 7.20 g. From a dietary standpoint, these results indicate that the lysine content of water hyacinth is in sufficient concentration to serve as an effective supplement to grain protein.

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TABLE 3. Amino Acids Per 100 g of Protein in Water Hyacinth Compared with F.A.O. Reference Pattern, Leaf, Corn and Milk.

	Met	(NE) Cys	Phe	(NE) Tyr	Thr	Lys	Ileu	Val	Leu
F.A.O.[1]	2.2	1.9	2.8	2.8	2.8	4.2	4.2	4.2	4.8
Water Hyacinth	0.7	11.6	4.7	3.0	4.3	5.3	4.3	0.3	7.2
Leaf Prot. Conc.[2]	2.1	0.7	6.0	4.2	5.2	6.3	5.3	6.3	9.8
Cow's Milk[1]	2.4	----	4.9	5.1	4.6	7.8	6.4	6.9	9.9
Corn grits[3]	2.5	1.1	6.4	6.7	4.1	0.8	6.4	5.3	15.0

[1]Burton, B. T. (10). [2]Stahman (11). [3]Block and Weiss (12).