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Nutritional and Phytochemical Quality of Some Tropical Aquatic Plants

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Abstract

This study investigates the nutritional and phytochemical composition of some selected aquatic plants to serve as indexes of nutritional values for both domesticated aquatic and terrestrial animals. Freshly harvested *Nympheaa lotus* (water lily), *Pistia stratiotis* (water lettuce), *Eichorrnia crassipes* (water hyacinth) and *Ipomoea aquatica* (water spinach) were collected from Upper Jebba Basin, Niger State, Nigeria. The plants were cleaned to remove dirt, air-dried, grind and analysed for the proximate, minerals (macro and micro elements) contents and phytochemical properties (quantitative) using standard procedures. The result show that water spinach had the least mean moisture content of 6.25 ± 0.87% while water lily has the highest mean concentration of 8.78 ± 1.09% and significantly difference from other sampled plants (p>0.05). The percentage ash content of the samples shows a high value for water lettuce (16.20 ± 0.46) and also significant among the plant samples. The water lily recorded the lowest value of 9.0 ± 0.50% for crude fibre with water spinach having the highest (18.38 ± 0.88%) at a significant level (p>0.05). The crude protein of (26.45 ± 1.12%) in water spinach and (23.27 ± 0.85) in water lettuce are comparatively higher to17.93 ± 1.02% and 17.23 ± 0.02 recorded in water lily and water hyacinth respectively. Crude fat of 14.10 ± 1.15% in water lettuce is significantly lower to other plants. The carbohydrate level of 34.92 ± 1.53 is the highest in all plants analysed while the lowest content (22.12 ± 0.03%) was found in water spinach. For minerals content; K concentration was the highest of all macro-mineral elements, though varied among the sampled plants. Water spinach has the highest concentration of all analysed elements (9.82 for K; 4.24 ± 0.01 for Mg; 3.35 ± 0.01 for Ca and 3.23 ± 0.02 for Na)g/kg followed water lettuce, water hyacinth and water lily. The amount of Fe found in all sample was higher and range from 186.30 ± 0.10 µg/g in water lily to 197.5 ± 0.05 µg/g in water spinach while Cu, Mn and Zn are also constituted. The presence of some important phytochemical such as alkaloids (2.68 ± 0.01 µg/mg - 4.12 ± 0.01 µg/mg), saponin (1.27 ± 0.03 µg/mg - 1.38 ± 0.01 µg/mg), etc in all the plant samples could also makes the plants pharmacologically active and could be considered as good feed supplement by virtue of their proximate composition.

Keywords: Aquatic plants; Elements; Nutritional; Phytochemical; Proximate

Introduction

Aquatic plants grow profusely in lakes and waterways all over the world and have become weedy in many lakes and ponds. These may be categorized as floating submerged and emergent aquatic plants. For centuries, aquatic plants have been perceived as a nuisance rather than resource with its eradication proved almost impossible and even reasonable control is difficult [1]. In recent times their negative and positive effects/implication magnified by man's intensive use of natural water bodies with its disadvantages associated with this alarming growth rate include nuisance to fisheries, water transportation (navigation), blocking of water supply system and hydro-electric power generation. This plant however has some positive uses; turning these plants/weeds to productive use would be desirable if it would partly offset the costs involved in mechanical removal. Among other uses, there has been considerable interest in using aquatic plants as a source of animal feed (Ali et al. [2] Aboud et al. [3] Anon [4] including fish feed formulation Little [5]. Studies have also shown that the plant serves as a phytoremediation agent Sajn et al. [6] as a biosorbent for toxic metals Malik [7], for power alcohol and biogas production (Ali et al. [8] Mshandete et al. [9] as a compost Szczeck [10] and as medicinal plants Deepa et al. [11] Nagma and Sarwat [12] Nandkarni [13]. Also, in its natural form and at low infestation, it serves as fish food, where herbivorous fishes are stocked and cultured in combination with other non-predatory species to promote the growth of fish [14]. In China for example, presence of small quantities of water hyacinth is encouraged it fish ponds because fish find food among the roots.

Among all these uses, there has been considerable interest in using aquatic plants as a source of animal feed [2,4]. Animal feed is expensive and can account for 60% of the variable cost especially in a fish culture operation and this has forced nutritionists to consider alternative sources of plant based protein source such as Soy beans, groundnut cake and others at low cost for fish [15]. The use of aquatic plants in animal feed will reduce the present dependence on these competitive agricultural crops used in compounding feeds.

The use of these aquatic plants in animal feed will reduce the present dependence on other competitive agricultural crops used in compounding animal feeds. However, before advocating the utilization of these aquatic plants for supplementation of animal feeds, there is need to explore the nutritional composition. Hence, this study investigates the nutritional potential of *Nympheaa lotus* (water lily), *Pistia stratiotis* (water lettuce), *Eichorrnia crassipes* (water hyacinth) and Ipomoea aquatic (water spinach) to serve as indexes of nutritional values for both domesticated aquatic and terrestrial animals.

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Methodology

Collection of sample plants

Freshly harvested *Nympheaa lotus* (water lily), *Pistia stratioties* (water lettuce), *Eichorrnia crassipes* (water hyacinth) and *Ipomoea aquatica* (water spinach) were collected from Upper Jebba Basin, Niger State, Nigeria. The plants were identified with the aid of keys compiled by Obot and Ayeni and registered in the herbarium of National Institute of Freshwater Fisheries Research (NIFFR), New Bussa, Niger state [16]. The plants were cleaned to remove dirt, air-dried for three days and finally ground in an electric mill (National Food Grinder, Model MK308, Japan). It was then passed through a 40 mesh sieve and stored in plastic containers at a room temperature until use. The proximate, minerals (macro and micro elements) and phytochemical analysis were carried out in the laboratory of Institute for Agriculture Research and Training (IAR&T), Moor plantation, Ibadan, Oyo State, Nigeria.

Proximate analysis

The chemical analysis of percentage crude protein, crude fiber, moisture, ash, fat and carbohydrate were carried out using methods described by AOAC [17]. All determinations were done in triplicates.

Mineral analysis

The mineral contents namely, calcium, magnesium, copper, manganese, iron, zinc, were determined using dry ashing procedure and Atomic Absorption Spectroscopy (AAS) (AA 800, Perkin-Elmer Germany) as described by AOAC [17]. Sodium and potassium were determined by flame emission techniques.

Anti-Nutritional Analysis

Anti-nutritional evaluation were carried out and the percentage proportion of the respective anti-nutritive factors such as tannins, saponins, oxalate, alkaloids, flavonoids, steroids and cardiac glycosides were evaluated according to the standard chemicals procedures [18].

Data analysis

All data generated was analyzed using descriptive statistic as described by Olawuyi [19].

Result

Proximate composition of (g/100 g of dry weight) some aquatic plant

The proximate composition of water lily, water lettuce, water hyacinth and water spinach are presented in Table 1. Moisture, ash, crude fibre, crude protein, crude fat and Carbohydrate (Nitrogen Free Extract) existed in percentage. Water spinach had the least mean moisture content of 6.25 ± 0.87% while water lily has the highest mean concentration of 8.78 ± 1.09% and significantly difference ($p>0.05$). The percentage ash content of the samples shows a high value for water lettuce (16.20 ± 0.46) and also significant among the plant samples. The crude fibre recorded the lowest value of 9.0 ± 0.50% for water lily in all the samples while water spinach has the highest (18.38 ± 0.88%) at a significant level ($p>0.05$). The crude protein of (26.45 ± 1.12%) in water spinach and (23.27 ± 0.85) in water lettuce are comparatively higher to17.93 ± 1.02% and 17.23 ± 0.02 recorded in water lily and water hyacinth respectively. Crude fat of 14.10 ± 1.15% in water lettuce is significantly lower to other plants. The carbohydrate level of 34.92 ± 1.53 is the highest in all plants analysed while the lowest content (22.12 ± 0.03%) was found in water spinach.

Macro-mineral composition of some aquatic plants (g/kg of dry weight sample)

The concentration of sodium (Na), calcium (Ca), magnesium (Mg) and potassium (K) found in water lily, water lettuce, water hyacinth and water spinach are shown in Figure 1. K concentration was the highest of all macro-mineral elements, though varied among the sampled plants. Water spinach has the highest concentration of all analysed elements (9.82 for K; 4.24 for Mg; 3.35 for Ca and 3.23 for Na)g/kg followed water lettuce, water hyacinth and water lily. The lowest macro-mineral element in the study is Na (2.84 g/kg) in water lily (Figure 1).

Micro-mineral composition of some aquatic plants (µg/g of dry weight sample)

Figure 2 shows iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) quantity present in water lily, water lettuce, water hyacinth and water spinach. The amount of Fe found in all sample was higher and range from 186.30 ± 0.10 µg/g in water lily to 197.5 ± 0.05 µg/g in water spinach. Cu contains relatively lower concentration in all sample plants which range between 5.70 ± 0.10 µg/g in water lily to 7.60 ± 0.11 µg/g in water hyacinth. Water hyacinth contains a comparatively higher value of 118.30 ± 0.10 µg/g to 116.50 ± 0.11 µg/g in water spinach, 115.67 ± 0.0 5 µg/g in water lettuce and 113.10 ± 0.10 µg/g in water lily. Zn varies greatly with species water lettuce contained 64.67 ± 0.10 µg/g followed by 63.87 ± 0.03 µg/g in water spinach, while the least value of 61.37 ± 0.03 µg/g was found in water lily.

Phytochemical composition of (µg/mg of dry weight) some aquatic plant

Generally, anti-nutrient activities in plant interfere with different aspects of feed ingestion process. Table 2 shows the anti-nutrients composition of the four plants in µg/mg. All the samples comparatively contain high level of alkaloids (2.68 ± 0.01 µg/mg in water lily - 4.12 ± 0.01 µg/mg in water spinach). Total saponin content quantified were 1.27 ± 0.01 µg/mg, 1.35 ± 0.01 µg/mg, 1.27 ± 0.03 µg/mg and 1.38 ± 0.01 µg/mg in water lily, water lettuce, water hyancinth and water spinach respectively. Other anti-nutrients contained are tannin, flavonoids, anthraquinine and catachin in limited quantities.

Aquatic plants (Whole plant)	Nutrient parameters (g/100 g of dry weight)					
	Moisture	Ash	Crude fibre	Crude protein	Crude fat	Carbohydrate
A	8.78 ± 1.09^b	13.60 ± 1.24^b	9.00 ± 0.50^a	17.23 ± 0.02^a	16.47 ± 0.29^b	34.92 ± 1.53^d
B	6.70 ± 0.81^a	16.20 ± 0.46^c	14.13 ± 0.88^b	23.27 ± 0.85^b	14.10 ± 1.15^a	25.62 ± 0.23^b
C	7.57 ± 0.45^a	8.85 ± 0.21^a	17.78 ± 0.78^c	17.93 ± 1.02^a	16.62 ± 1.37^b	31.27 ± 1.86^c
D	6.25 ± 0.87^a	10.00 ± 0.66^a	18.38 ± 0.88^c	26.45 ± 1.12^c	16.81 ± 0.43^b	22.12 ± 0.03^a

Note: (A=*Nymphae lotus* (Water lily), B=*Pistia stratioties* (Water lettuce), *Eichorrnia crassipes* (Water hyacinth), *Ipomoea aquatica* (Water spinach)).
Values are mean ± standard error
Different superscript within the same column are significantly different ($p<0.05$).

Table 1: Nutrient composition of (g/100 g of dry weight) some aquatic plant.

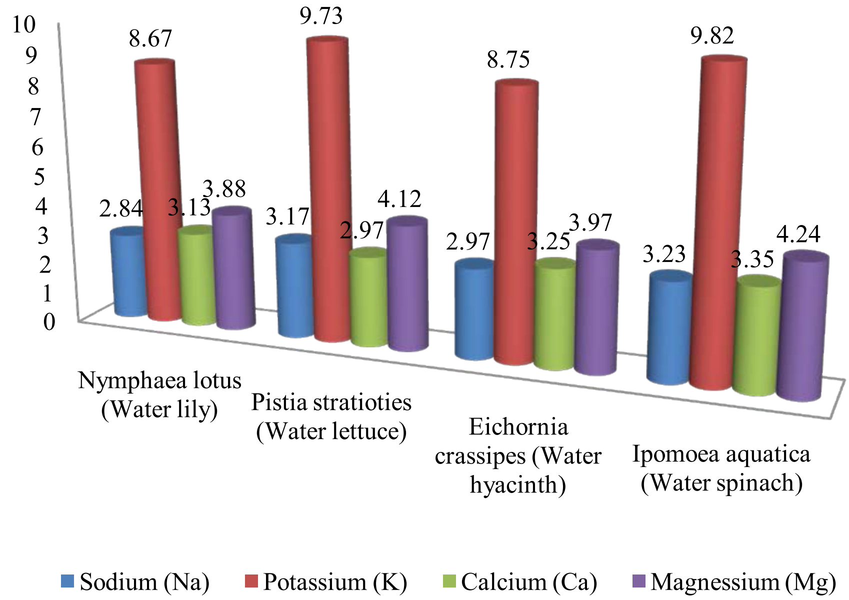

Figure 1: Macro-mineral composition of some aquatic plants (g/kg of dry weight).

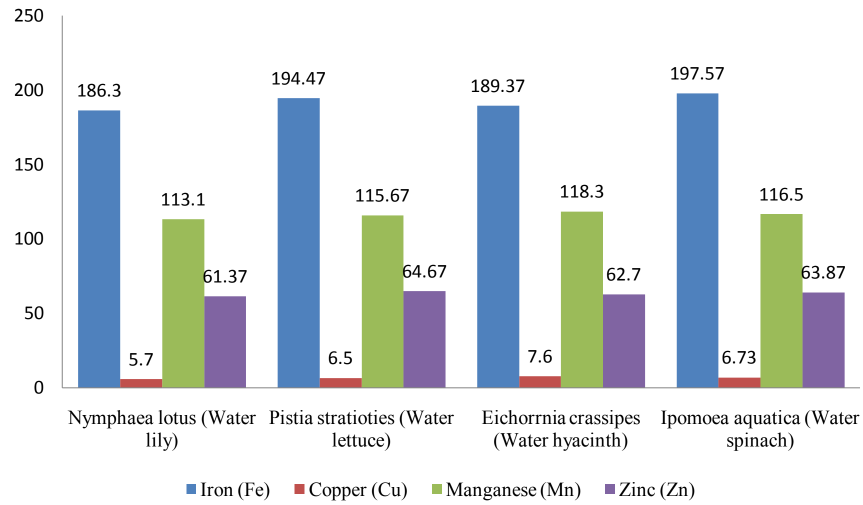

Figure 2: Micro-mineral composition of some aquatic plants (µg/g of dry weight).

Aquatic plant (Whole plant)	Phytochemical composition (µg/mg of dry weight)					
	Alkaloids	Tannin	Flavonoids	Saponin	Anthraquinine	Catachin
A	2.68 ± 0.01	0.23 ± 0.02	0.03 ± 0.00	1.27 ± 0.01	0.16 ± 0.02	0.38 ± 0.01
B	3.86 ± 0.01	0.17 ± 0.01	0.03 ± 0.00	1.35 ± 0.01	0.26 ± 0.02	0.44 ± 0.01
C	2.77 ± 0.03	0.27 ± 0.01	0.03 ± 0.00	1.27 ± 0.03	0.16 ± 0.01	0.47 ± 0.01
D	4.12 ± 0.01	0.35 ± 0.02	0.04 ± 0.00	1.38 ± 0.01	0.27 ± 0.01	0.42 ± 0.01

Note: (A=*Nymphae lotus* (Water lily), B=*Pistia stratioties* (Water lettuce), *Eichorrnia crassipes* (Water hyacinth), *Ipomoea aquatica* (Water spinach)).
Values are mean ± standard error.

Table 2: Phytochemical composition of (µg/mg of dry weight) some aquatic plant.

Discussion

In the study, all aquatic plants analysed were nutritious. The nutrient composition (including the minerals) recorded for the samples are within the range reportedly indexed for aquatic plants Banerjee and Matai, [20] except for crude fat which is relatively higher though fall within the range earlier reported by Boyd [21] for freshwater plants. The nutritional contents of water hyacinth have been justified by its inclusion in the diet of Clarias gariepinus probably due to its high nutritional contents and its low level of anti-nutrient which will make it more digestible [22]. The crude protein value for all plants is relatively higher than the value reported for Nephrolepsis biserrata;

an aquatic plant documented to be feed resource for small ruminant [23]. The presence of these essential nutrients and minerals imply that these aquatic plants could be utilized as animal feed ingredient. Some of these minerals are constituted than some in forage crops [24]. The tissue chemistry of aquatic plants has been reported to show considerable variation in mineral composition which may be attributed to the age and types of plants sampled, and the fertility of the aqueous environment [25].

The Phytochemical present in these samples can influence various body processes. They work together with nutrients and dietary fiber to protect the body against diseases, slow the aging process and reduce the risk of many diseases such as cancer, heart disease, stroke, high blood pressure etc.

Conclusion

The nutritional composition of four less economical aquatic plants was determined. It showed that water spinach had the highest percentage concentration of crude protein while water lily and water hyacinth are comparatively lower. All the sampled plants are considerably richer in mineral elements. The presence of the phytochemical in all the plant samples reported in this present study also makes the plants pharmacologically active and could be considered as good feed supplement by virtue of their proximate composition. Therefore, this present study revealed the presence of many medicinally important constituents in the plants studied apart from its nutritive values making these aquatic plants assessed a good potential ingredient in animal feed; some animal such fish may not accept them directly but it can be incorporated in the animal feed to provide all nutrient required daily at very low cost. Their regular harvesting for feed formulation could offset the cost of removal from water bodies where they are regarded as nuisance. These plants could also be tried as non-conventional feedstuff especially in less protein demanding animal feed.

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