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EXPLORING THE NUTRIENT POTENTIAL OF *NYMPHAEA ALBA* (WATER LILLY), FOR USE AS LIVESTOCK FEED

***Abarike, E. D., Amenyogbe, E., Ampofo-Yeboah, A., Abobi, S. M., Atindaana, S. A., Alhassan, E. H., Akongyuure, D. N.**

Department of Fisheries & Aquatic Resources Management, University for Development Studies. P. O. Box TL 1882, Tamale.

[*]Corresponding author: delwindelwin024@gmail.com

Abstract

The study aimed at finding the nutrient composition of Nymphaea alba to help control the growth of the aquatic plant as it hinders the livelihoods of people who use the Banka dam for fishing and irrigation. The leaves, leaf stalks and flowers of Nymphaea alba were sampled to determine the crude protein, crude fibre, the nitrogen free extract, ether extract, total ash and some minerals. The study revealed that, the leaf stalks of the plant has significantly (P < 0.05) more ash (19.25 % - 20.59 %) than there is in the leaves and flowers with the leaves significantly (P < 0.05) richer in protein (20.91% - 25.40 %). Fibre concentration was highest in leaf stalks (12.84 % - 15.14 %) with low levels of ether extracts (1.10 % to 3.82 %) in the entire plant. Nymphaea alba is rich in nitrogen free extract (53.09 % - 56.57 %) in all of its parts, thus the leaf stalks, leaves and flowers. Potassium (1.56 % – 4.63 %) and sodium (1.97 % - 4.21 %) were the dominant minerals with calcium, zinc, iron and copper equally present in Nymphaea alba in all of its parts investigated. The respective levels of crude protein, fibre, nitrogen free extract, lipids, ash and minerals are adequate for use as feed for livestock. However, there is the need for studies on palatability and digestibility of the aquatic plant as these affect utilization by livestock.

Keywords: Nymphaea alba, crude fibre, crude protein, nitrogen free extract, mineral

Introduction

Water lily is an aquatic herb of genus Nymphaea, family Nymphaeaceae. It serves as an ornamental plant, a water purification plant, and also as a beverage plant as the roots can both be made into tea and liquor, and the whole plant has been useful in the therapies of nephritis (Zhu, Zheng, Shu, Li, Zhong, Zhang, Xu, Wang, & Wang, 2012). In some communities, in the Northern region of Ghana, the fruits of the water lily plant is eaten as food.

Aquatic plants that grow in and around water bodies have various uses, for instance, considering the importance of nutritionally balanced and cost-effective alternative diets for livestock (fish), lemna (*Lemna minor*), water hyacinth (*Eichhornia crassipes*) and azolla (*Azolla pinnata*) have been evaluated and recommended for is used as feed (Bag, Mahapatra Rao, 2012). Underutilized aquatic plants have been problematic as they block canals, reduce dissolved oxygen levels in water or compete with other organism for oxygen intake in water bodies as well as interfering with fishing activities as they entangle nets (Deepa, Usha, Nair & Prasanna (2009).

In Ghana, among the aquatic weeds that abounds water bodies, the dominant plant that grows from the shallow portion of a water body to the deepest part is the water lily plant. An observation of water bodies in the Tolon district in the Northern Region of Ghana in the early dry season (October-December) reveals blankets of water lily plants covering their surfaces (see plate 1 as a case in point of the situation in the Banka Dam in the Tolon district). Water lilies, often, are conserved in water bodies because the leaf stalks have little effect on flow and the shading effect of the floating leaves help to suppress the growth of more troublesome submerged plants. This reflects the ecological description of water lily by Shah, Sumbul & Andrabi (2010). However, if left unchecked they can produce a dense cover on the water surface and control is sometimes necessary. Therefore, the study was designed to explore the nutrient potential of this plant (Water lily) to find a suitable use for it and at the same time reduce its negative effects on the water body.

Materials and Methods

Study Area

The study was carried out at Banka dam (plate 1) with a catchment area sharing boundaries with the Kukpehi, Panlebianle communities and that of the eastern boundary of the University for Development Studies, Nyankpala campus in the Northern Region of Ghana. Banka dam located in the Tolon District and it is about 18 km away from Tamale the Regional capital of Northern Region. Its geographical coordinates are 9° 24' 0" North, 0° 59' 0" West (Source: field survey data)

Plate 1: Banka dam covered with aquatic weeds with *Nymphaea alba* dominating in the pelagic region

Sample Collection and Preparation

Samples for the study were collected in the months of October and December 2013. This study period was chosen because, that is the time many of the plants have fully developed plant parts (leaves. flowers and leaf stalk) and in appreciable quantities. During each sampling time, adequate quantities of the leaves, flowers and leaf stalks of *Nymphaea alba*, were collected at random manually from the pelagic zones of the dam at different locations in fresh green conditions. Samples were washed in running tap water to get rid of soil particles and unwanted materials.

Chemical Analysis of Plant Samples

Proximate analysis of the plants for the experiment was carried out at the animal nutrition laboratory of the School of Agriculture, University of Cape Coast, following the procedures that broadly adhere to the Association of Official Analytical Chemists [AOAC] (1990). The protocol was used in determining the % crude protein (CP), % ash, % ether extract (EE) and % crude fibre (CF). Nitrogen-free extract was computed using the formula: % NFE = 100 - (% CP + % CF + % EE + % Ash). Minerals such as phosphorus (P) was determined using the colorimetric determination (ascorbic acid method) method, potassium (K) and sodium (Na) were determined using the flame photometer, calcium (Ca) and magnesium (Mg) using the diaminetetra-acetic acid (EDTA) titration method and the atomic absorption spectrophotometer (AAS) was used in determining the iron, copper and zinc levels in *Nymphaea alba.*

Statistical Analysis of the Plants Samples

Data were subjected to a non-parametric test (Kruskal Wallis test) using Statistical Package for Social Sciences (SPSS) to determine if there were any variance in means.

Results

Nutrient Analysis of *Nymphaea Alba* in Sample 1 (October 2013)

In October, illustrated in Figure 1, the ash content ranged from 7.11 % in the flower to 20.59 % in the leaf stalks. Protein was highest in the leaves (25.40 %) and lowest in the leaf stalks (10.00 %). Fiber was in the order 9.5 % < 12.3 % < 15.1 % in the leaves, flowers and leaf stalks respectively. Ether extract was found to be lowest (1.10 %) in the leaf stalks and highest (3.81 %) in the flower. Nitrogen free extract scored the highest percentages with a minimum of 53.2 % in the leaves and a maximum of 55.6 %

occurring in the lowers. (52.77 %) to leaf stalks highest (53.2 %). In all plant parts, a test of significance revealed that with the exception of the nitrogen free extract which were similar in the leaves and leaf stalks, all other nutrients investigated were significantly different in all plant parts.

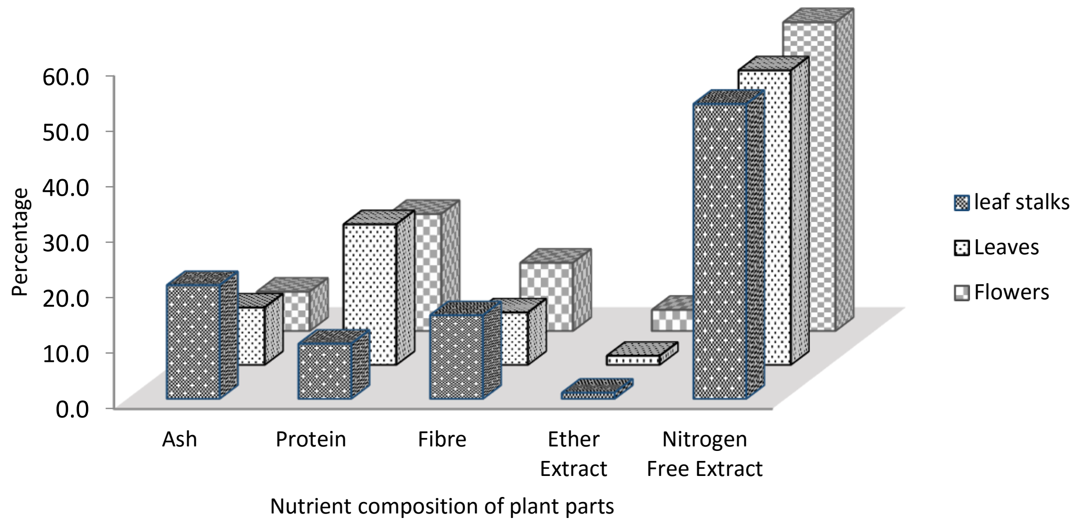

Figure 1: Nutrient composition of *Nymphaea alba* in October, 2013

Nutrient Analysis of *Nymphaea Alba* in Sample 2 (December 2013)

Similarly, in December 2013, the ash content from plant parts tested revealed that the flowers scored the lowest (7.41 %) and the leaf stalks scored the highest (19.25 %). Protein was in the order 9.96 % < 20.91 % < 21.13 % in the leaf stalks, leaves and flowers respectively. Fibre was minimal in the leaves (9.39 %) and highest in the leaf stalks (12.84 %). Ether extract was between 1.53 % and 3.42 % in the entire parts investigated. Nitrogen free extract ranged from 54.18 % in the leaves to 56.67 % in the leaf stalks.

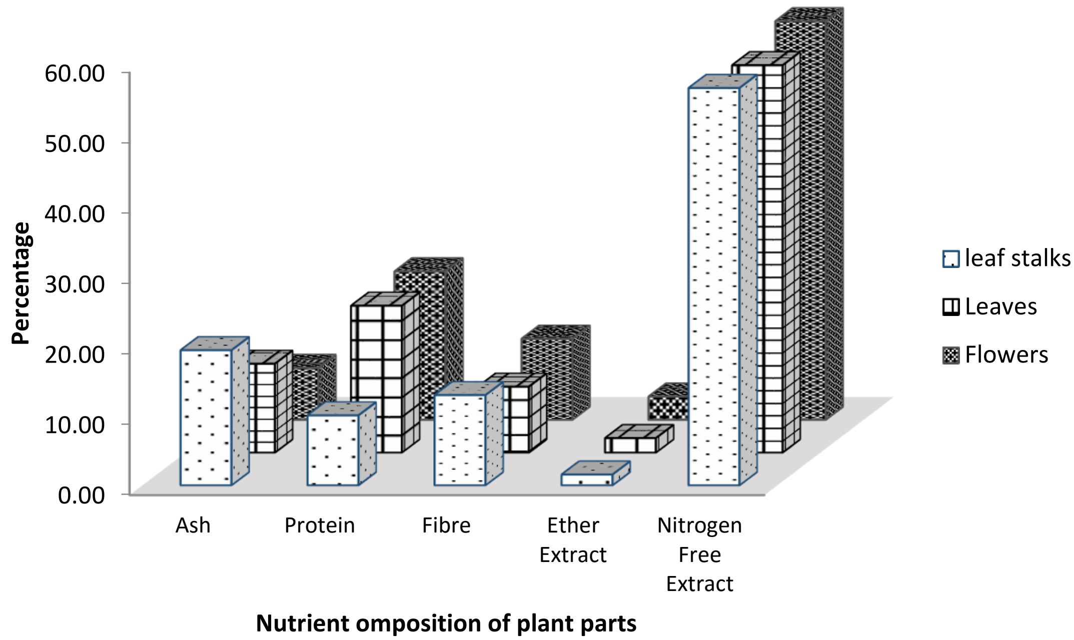

Figure 2: Nutrients composition of *Nymphaea alba* in December, 2013

Illustrated in Table 1 is a contrast among the nutrients investigated in *Nymphaea alba* in various parts of the plant after data for the two samples were pooled together. Ash contents in *Nymphaea alba* from the two samples taken from the waterbody ranged from 7.11 to 20.59 %. Contents were highest in the leaf stalk and lowest in the flowers. Protein was highest in the leaves (20.91 - 25.40 %) and lowest in the leaf stalk (9.96 - 9.97 %). Fibre levels were in the order 9.39 - 9.49 % < 11.56 - 12.34 % < 12.84 - 15.14 % for the leaves, flowers and leaf stalk. Lipids were more in the flowers 3.33 - 3.82 % followed by 1.10 - 1.53 % in the leaf stalk and 1.64 - 2.06 % in the leaves of *Nymphaea alba*. Nitrogen free extract was similar in the leaf stalk, leaves and flowers and ranged from 53 .09 – 56.57 %. A test of significance using the Kruskal Wallis test shows that the ash, protein and lipids levels were significantly ($P < 0.05$) different among the plants parts whiles fibre and nitrogen free extract were not significantly ($P > 0.05$) different.

Table 1: Nutrients contrast in different parts of *Nymphaea alba* using Kruskal wallis test

Nutrients	Plant part in percentage			Chi-square value	df	P-value	SD
	Leaf stalk mean range (Oct – Dec)	Leaves mean range (Oct – Dec)	Flowers mean range (Oct – Dec)				
Ash	19.25 - 20.59	10.39 - 12.65	7.11 - 7.41	11.81	2	0.003	S
Protein	9.96 - 9.97	20.91 - 25.40	21.12 - 21.13	13.46	2	0.001	S
Fibre	12.84 - 15.14	9.39 - 9.49	11.56 - 12.34	3.25	2	0.196	NS
Ether extract (Lipid)	1.10 - 1.53	1.64 - 2.06	3.33 - 3.82	14.26	2	0.001	S
Nitrogen free extract	53.20 - 56.42	53.09 - 54.99	55.60 - 56.57	4.55	2	0.103	NS

SD = Significant difference, S = significant, NS = Not significant, df = degree of freedom

Mineral Analysis of *Nymphaea Alba*

In both sampling times thus in October and December, minerals occurring at higher levels in plant parts were potassium and sodium. In terms of percentage composition, these components formed the largest share with a range of 1.56 - 4.63 % and 1.97 – 4.21 % for potassium and sodium respectively. Calcium was relatively higher compared to zinc, iron and copper in *Nymphaea alba*. As shown in Table 2, among the parts under study, the levels of calcium, potassium, sodium and phosphorus were significantly ($P < 0.05$) different whiles that of iron, copper and zinc were not significantly ($P > 0.05$) different.

Table 2: Mineral composition of *Nymphaea alba* using Kruskal Wallis test

Minerals	Plant parts in percentage			Chi-square value	df	P-value	SD
	Leaf stalk mean range (Oct - Dec)	Leaves mean range (Oct - Dec)	Flowers mean range (Oct - Dec)				
Calcium	1.60 - 1.80	1.13 - 1.60	1.37 - 1.58	7.45	2	0.024	S
Iron	0.06 - 0.08	0.16 - 0.19	0.05 - 0.22	3.78	2	0.150	NS
Copper	0.01 - 0.01	0.01 - 0.01	0.01 - 0.01	4.02	2	0.134	NS
Zinc	0.01 - 0.02	0.01 - 0.02	0.01 - 0.02	1.29	2	0.526	NS
Potassium	4.61 - 4.63	1.56 - 1.74	1.98 - 2.01	15.16	2	0.001	S
Sodium	4.13 - 4.21	2.07 - 2.23	1.97 - 2.11	11.94	2	0.003	S

Phosphorus	0.20 - 0.27	0.30 - 0.46	0.29 - 0.41	6.42	2	0.039	S

Where: SD = Significant difference, S = significant, NS = Not significant, df = degree of freedom

Discussion

The results indicate that the plant parts under discussion have much stores of its protein in the leaves and the flowers. It would imply that diets to be enriched with protein using aquatic macrophytes and in the case of *Nymphaea species* should concentrate on the leaves and flower parts. It is important to note that incorporating/using Nymphaea as feed for animals should not only be based on the nutrient content, as reported in this study rather, other consideration for example the extent of utilization thus its palatability and digestibility should together prove the usefulness of the feed. In figures 1 & 2 the crude protein range from 20.91 – 24.4 % and 21.13 – 21.13 % in the leaves and flowers respectively. These are much higher than as reported by Akmal , Hafeez-ur-Rehman, Ullah, Younus, Khan & Qayyum 2014) for crude protein in the leaves and stem of the water lily as 18 % and 16.4 %. Aquatic plants have the ability of accumulate nutrients introduced into water bodies from external nutrient loading. (Shardendu, Sayantan, Sharma, & Irfan, 2012) Nutrients in water can be removed by aquatic plants through accumulation. The amount of nutrients found in aquatic plants is directly dependent on amount of nutrient in the water column. This points to the fact that the higher the nutrient loading from external sources the higher the accumulation in the plants.

Rashid (2008), reported that in roughages (hay) and cereals used as feed for goats contains a crude protein in the range of 12-13 % and 7 – 8 %. In fish, the protein requirements of fingerling of Tilapia as reported by Boyd (2005) range from 30-56 %. *Nymphaea alba* appears to be better suited as a protein supplement for livestock such as goats but would have to be supplemented with other sources of protein to meet the optimal requirement of the fish.

Nymphaea alba in the Banka dam has a lower representation of fibre in the leaves than in the flowers and leaf stalk, these are however, similar ($P > 0.05$) (Table 1). This would mean that, fibre levels in any part (leave, flowers and leaf stalk) of *Nymphaea* would present the same effects because fibre accumulation is not significantly different in any of the plant parts. In figures 1 & 2 fibre ranged from 9.39 – 9.50 %, 11.56 – 12.30 % and 11.84 – 15.1 % in the leaves, flowers and leaf stalk respectively. This agrees with Shah *et al.* (2010) explanation that, higher fiber content in *Nymphaea* and *Nymphoides* may be due to the fact that floating plants require more strength to support aerial vegetation. The higher fibre contents in the leaf stalk can explain the fact that the leaves and flowers need to be held in position to receive sunlight and air for photosynthesis and respiration as well as resist the effects of moving currents be it water or wind. In Akmal *et al.* (2014) buoyancy in aquatic plants can explain the reason why there is little need for structural material (fibre or lignin) in some of their tissues. In concord of this explanation, it is believed that buoyant structural material is needed more in the leaves of Nymphaea species than there is in the leaf stalk and flowers. This probably explains why as revealed in this study the fibre is lower in the leaves. In comparism to other previous studies, the crude fibre content of N*ymphaea alba* for example in Mohammed, Uka & Yauri, (2013) ranged from 9.39 - 15.13 % and Akmal *et al.* (2014) ranged from 9.32 – 15.23 % . Variance in fibre levels could be explained by the postulate of Kalita, Mukhopadhyay & Mukherjee (2007) that variations in plant nutrients could be attributed to differences pertaining to the different effects of anthropogenic activities within the catchments of the water body.

Rinehart (2008) reiterated the need for fibre in diets of some animals. For example fibre is necessary for proper rumen (compartment stomach in ruminants) function, as it is a source of energy as well. However, high levels of fiber in the diet decrease intake and is less digestible. In many omnivorous fish such as the *Oreochromis species*, fibre levels exceeding 8 -12 % in diets for fish would consequently lead to a decrease in usable nutrient. Older fish seems to cope with higher dietary fibre content (a maximum of 8 -10 %) than younger ones at about 6 - 8 % (Gonzalez & Allan, 2007; Audu, Adamu & Binga, 2008). In that regard the fibre levels in all plant parts investigated in the study are higher than the recommended levels. Rashid (2008) explained that fresh pastures and young plants may have highly digestible fibre and provide high energy compared to older plants. Higher energy levels come from lower fibre feeds. He encouraged the maintenance of fibre in the diets of goats not to exceed 12 %. This implies that, for *Nymphaea alba* to be used in the diets of livestock requiring fibre levels lower than 12 %, it would be advisable to purposely harvest younger plants. Younger plants are generally more digestible than mature plants. Plant samples were randomly collected from the dam for analysis, this means older and younger plants had equal chances of being selected. Therefore it cannot be said that plants samples collected in October were younger than those collected in December, what can be said here is that the older the plant there more likely that fibre contents will be high.

As shown in the figures 1 & 2 a chunk of the nutrient composition of *Nymphaea alba* is made of nitrogen free extract. The nitrogen free extract contents of the plant under investigation is fairly ($P > 0.05$) distributed in the parts (leafstalk, leaves and flowers). This implies *Nymphaea alba* is a good source of energy and that any of the parts investigated in this study can be sourced as energy for used. However, utilization of any of the parts of *Nymphaea alba* can be limited by other factors such as fibre levels and anti-nutrient factors. Nitrogen free extract in *Nymphaea alba* ranged from 53.10 – 56.57 %. This is in close agreement to the findings of Shah *et al.* (2010). Also as explained by Banerjee (1980) cited in Shah *et al.* (2010), *Nymphaea alba* should be preferred to other sources of feed such as in berseem hay and maize because of its higher energy levels provided it is utilizable.

Fats/Ether Extract are essential in diets as they increase the palatability of foods by absorbing and retaining their flavours and also vital in the structural and biological functioning of the cells and help in the transport of nutritionally essential fat-soluble vitamins (Omotoso, 2006). Lipid deposits in *Nymphaea alba* has the lowest representation among all other nutrients in the aquatic plant. Ether extract we believe may be needed to contribute to buoyancy of the plants as well as keep the tissues soaking with water. Ether extract level of *Hydrilla* (2.79 %), *Nymphaea* (1.5) and *Nymphoides* (3.5 %) as reported by Shah *et al*. (2010) are in close agreement to the findings (figures 1 and 2) of the current study but lower compared to the findings of Akmal *et al.* (2014).

Ash content in a feed item gives an indication of its' mineral (Omotoso, 2006). By this, we would say that the plant understudy is richer in minerals than in fats/ether extract/lipid in all of its parts. This is because ash ranged from 7.10 – 20.60 % with a higher representation in the leafstalk and a lower representation in flowers whiles lipids ranged from 1.1 – 3.8 % and an inverse relationship pertaining to the leaf stalk and flowers. The reason why ash contents may be higher in the leaf stalks than in other parts of the plants is beyond the scope of this study. This is because although plants directly harvested and dried to proper moisture level will contain higher ash levels due to soil and crustations inclusions in specimens analyzed. In this study, plants were washed carefully to remove soil particles and other materials. That notwithstanding, it can be said that the leaf stalk of *Nymphaea alba* can be explored to enrich diets with mineral supplements. In general, the ash level (7.10 – 20.60 %) in *Nymphaea alba* is good for used as livestock feed. This is because the ash contents in the present plants compare favourably to the ash levels of some commonly used green roughages feed for livestock with range 4.99 % to 20.47 % (Garg, Kannan, Shelke, Phondba & Sherasia, 2012).

Mineral elements play an important role in regulating many vital physiological processes in the body, such as regulation of enzyme activity (cofactor or mettalloexyme), skeletal structures (e.g., calcium and phosphorus), neuromuscular irritability and clotting of blood (calcium) (Soetan, Olaiya & Oyewole, 2010). Non-availability of adequate qualities of minerals in the diet affects growth of fish and ruminant as well and may cause irrecoverable deficiency diseases. The minerals composition of *Nymphaea alba* as shown in Table 2 shows wide variations in mineral content. Although potassium, sodium and calcium showed higher levels, others like calcium, phosphorus, iron, copper and zinc were equally represented in trace amounts.

In Rashid (2008), acceptable quantity of macro minerals in a goat's diet for calcium is 0.3 - 0.8%; phosphorus is 0.25 - 0.4 %, sodium is 0.2 % and potassium is 0.8 - 2.0 %. In the present study, *Nymphaea alba* seems to contain sufficient macro minerals that can support the growth of fish and goats, however, the levels of major nutrients such as calcium (1.13 – 1.60 %), potassium (1.53 – 4.63 %) and sodium (1.97 – 4.21 %) are in excess of the requirements of both goats and fish. This is a cause of concern because excesses and unbalanced nutrients in diets, not only depresses growth, but also affect the availability of other nutrients.

Trace (micro) minerals are essential chemical elements involved in the normal metabolism of fish. In a report by Rashid (2008), recommended micro minerals for goats for Iron is 50-1000 ppm (0.005 – 0.01 %), Copper is 10-80 ppm (0.001 – 0.008 %) and zinc is 40-500 ppm (0.004 – 0.05 %). The levels of trace elements such as iron (0.05 – 0.22 %), copper (0.01 %) and zinc (0. 01 – 0.02 %) of *Nymphaea alba* are higher compared to that which is required by goats and fish. If excess amounts of the elements are ingested and assimilated, toxicity may develop.

It is very important to note that, the mineral content of a feedstuff is of little value for ration formulation unless it is biologically availability otherwise it cannot promote growth. This is to say that although *Nymphaea alba* is mineral rich, it only can be useful if these minerals can be biologically available to animals feeding on it. Also, to take into consideration is the fact that the mineral contents vary (Table 2) in the different plant parts. This to say that for minerals such as calcium, potassium, sodium and phosphorus, there is great variety ($P < 0.05$) in the different plant parts that of copper and zinc as realized in this study are similar ($P > 0.05$).

Conclusion

Nymphaea alba is a rich source of energy as represented by the high level of nitrogen free extract. Crude protein is high in the leaves and flower, fiber high in the leaf stalks, lipid levels generally are low in all plant parts and ash content high in the leaf stalks. In terms of the mineral composition, potassium, sodium and calcium levels are high whiles copper and zinc are low.

Recommendation

Further studies on the anti-nutrient factors, presence of toxins, palatability, and digestibility of *Nymphaea alba* is necessary to ascertain its potential for use in the preparation of feed.

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