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CHEMICAL, NUTRITIONAL AND ANTI-NUTRITIONAL COMPOSITIONS OF *NEPHROLEPIS EXALTATA* (L.) SCHOTT. (NEPHROLEPIDACEAE)

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ABSTRACT
Chemical, nutrient and anti- nutrient compositions, elemental analysis and toxicity potentials of bipinnate and unipinnate leaflets of *Nephrolepis exaltata* were determined, evaluated separately and compared the nutritious potentials between the two types of leaflets statistically. Fresh, healthy, matured leaflets were collected from the two frond types, washed, air dried in the laboratory, ground and analyzed for proximate analysis, elemental compositions, dry matter, ascorbic acid, oxalate, phytate and cyanide contents in triplicate. The results of the proximate analysis showed protein (9.45±0.21, 12.47±0.08%), crude fibre (0.57±0.32, 0.47±0.30%), fat (0.47±0.40, 0.54±0.41%), ash (0.87±0.02, 0.93±0.11%), moisture (82.65±0.04, 78.50±0.05%), carbohydrate (5.98±0.16, 7.08±0.18%); dry matter (17.53±0.51, 21.50±0.72 g/100 g) and ascorbic acid (52.80±0.89, 69.96±0.01 mg/100 g) of bipinnate and unipinnate leaflets respectively. The result showed that the leaflets contains mineral elements such as potassium, sodium, calcium, iron, zinc, cadmium, lead, magnesium, manganese, copper, chromium and nickel; cyanide (0.12, 0.53) mg/100 g, oxalate (0.02, 0.02 mg/100 g) but phytate and arsenium were not detected from both bipinnate and unipinnate leaflets respectively. The cyanide and oxalate contents of both leaflets are very low and fall within the safe and acceptable limits as recommended by World Health Organization. Thus, they are potential good sources of dietary energy, protein, ascorbic acid and mineral contents in livestock diet. Unipinnate leaflets have significantly higher values ($p<0.05$) in most of the nutrients, therefore it is more nutritious.
Keywords: Leaflets, livestock feed, *Nephrolepis exaltata*, proximate analysis, toxicants

INTRODUCTION

The genus *Nephrolepis* belongs to the family Nephrolepidaceae, Order Filicales and class Pteropsida (David, 1987). It is commonly called Wild Boston fern or common sword fern while it is called "omu" in Yoruba. In *Nephrolepis exaltata*, sori are usually covered by indusia and are arranged on the abaxial surface of the unipinnate leaflets. It is a terrestrial fern growing on the soil in humid environments. It is an erect plant with fronds 50-250 cm long and 1.0-1.5 mm in diameter with 2-8 cm long pinnae which are alternately arranged on either side of the rachis. It possesses both bipinnate and unipinnate fronds on the same plant or separately on different plants. The bipinnate fronds possess sterile, beautifully arranged curled leaflets while the unipinnate fronds possess fertile, linear leaflets. It is a deciduous, medium-sized, herbaceous plant which is widely cultivated as an ornamental plant for beautification of homes and offices and for landscaping at Obafemi Awolowo University, Ile-Ife where ants and insects were seen feeding on its leaflets. It is edible because the tuber is eaten by children raw, as snack and for beer making (Gauchan *et al.*, 2008). Fashakin (1999) also reported that leaf protein concentrates of water ferns (*Azolla africana* Desv) and duckweed (*Spirodella polyrrhiza* L. Scleid.) contain low cyanide, tannin and phytic contents but contain high protein contents. The intake of *N. biserrata* by ruminants in the tropics is due to its high nutritive potential and can be used as fodder for feeding West African dwarf goats (Babayemi *et al.*, 2006; Oloyede *et al.*, 2008).

Agriculture plays key roles in economic growth, reducing poverty and hunger in many developing countries. Most of developing countries that failed to launch agricultural revolutions are trapped in poverty, hunger, malnutrition and economic stagnation. The situation is even worsened by lack or insufficient availability of feed for livestock and other ruminant animals especially during the dry season (Hazell, 2006; Belewu *et al.*, 2008). Belewu *et al.* (2008) also reported that the raising of ruminant animals under traditional and subsistence agricultural systems involve low quality feed. Poor performance of the animals occur as a result of the use of cheaper and lesser known and unconventional feed supplements which represent low-cost towards improving animal yields. Lack of information on the specific nutrient in a large number of natural vegetable species with which Nigeria is widely endowed is partly responsible for their under exploitation in areas beyond the traditional and local communities where they are found and consumed (Fashakin, 2004). In this regards, searching for protenous meat and fish of good quality, high yields with low toxic levels is on the increase worldwide. Many attempts have been made in evaluating the chemical, nutrient and anti-nutrient compositions of some higher plants but there were little efforts toward lower plants. As valuable as these lower plants especially *N. exaltata* are, they are unrecognized and underutilized especially in developing countries. Thus, this work was designed to investigate, evaluate and determine the presence (and quantity) or absence of toxins; nutritional and anti-nutritional potentials as well as elemental compositions of the two types of leaflets of *N. exaltata* and to determine which of the two leaf types is more nutritious. This is to ascertain its use as a fodder for feeding domestic animals and the possibility of its inclusion in livestock and fish feeds for high yield, good quality meat especially in developing countries.

MATERIALS AND METHODS

Nephrolepis exaltata was monitored for growth, developments and herbivore interactions for two seasons each in 2012 and 2013. Fresh leaflets of bipinnate and unipinnate fronds of *Nephrolepis exaltata* were collected from matured healthy plant at the Department of Botany, Obafemi Awolowo University, Ile-Ife where it is being cultivated for ornamental purposes. The plant was identified using IFE herbarium specimens at OAU, Ile-Ife. 2 g weighed leaflet each was taken from the two frond types, washed with distilled water, air dried in the laboratory, digested and used for the analyses. All the chemicals used for this work were of analytical grades and all the analyses were done in triplicate.

Proximate analysis

Crude protein content was calculated by converting nitrogen content obtained by Kjeldahl method (N x 6.25) using high pressure liquid chromatography. The moisture content was determined by drying 10 g of the samples in the oven at 80°C for 48 hours and expressed in percentage moisture contents. The lipid content was determined by continuous extraction by Soxhlet extraction method while crude fibre and ash contents were determined using the methods described by AOAC (1990). Total carbohydrate was calculated as the gross energy contents using an adiabatic calorimeter bomb (IKA C7000, Staufen, Germany) calibrated by benzoic acid. The ascorbic acid was determined by dyestuff titration using 50 ml of the sample in a burette. Titrate it with 25 ml of 2, 6-dichloroindophenol until the light rose colour changed to pink colour and persisted for about 5-10 seconds. This standardization was repeated three times, mean value was calculated and recorded for both bipinnate and unipinnate leaflets of *N. exaltata* separately.

Elemental analysis

Concentrations of Cd, Mn, Cr, Cu, Pb, Ni, Zn, As, Mg and Fe were determined using Atomic Absorption Spectrophotometer (Model: Perkinelmer) while Na^+, K^+, Ca^{++} concentrations were done using flame photometer (AAnalyst no. 400) as described by AOAC (2005).

Determination of toxicants

Hydrogen cyanide content (as a toxicant) was estimated by alkaline titration using 0.02 N $AgNO_3$ titrated with 8 ml of 5% KI solution. The end point of titration changed to light yellow, 1.00 ml of 0.02 $AgNO_3$ = 1.08 mg of HCN AOAC (2005).

Evaluation of anti-nutrient substances

Oxalate was determined using HPLC as described by Wilson *et al.* (1982). Extraction of phytic acid content from both the bipinnate and unipinnate leaflets of *N. exaltata* was based on the procedures of Fruhbeck *et al.* (1995) with some modifications as described by Norazalina *et al.* (2010).

Statistical Analysis

Statistical analysis was carried out using T-test to determine the level of significant in moisture, protein, crude fibre, carbohydrate, fat and ash; dry matter and ascorbic acid; oxalate; hydrogen cyanide; K, Na, Ca, Fe, Zn, Cd, Pb, Mg, Mn, Cu, Cr, Ni and As between the two leaflets ($p>0.05$). The statistical analysis was done using SPSS model 17.0 and it was done at 95% probability level ($p<0.05$) and the sample size is 3 (3 replicates).

RESULTS

N. exaltata is a perennial plant capable of growing over the years accumulating heavy biomass and readily available both during the rainy and dry seasons producing bushy and drooping fronds. The bipinnate frond consists of sterile, tuft, soft, finely coiled green leaflets that are beautifully arranged alternately on the rachis. The unipinnate frond possesses fertile, glabrous, simple and linear shaped, green coloured leaflets with smooth margins. The result of chemical and proximate compositions of the two fronds of *N. exaltata* was determined separately. Unipinnate leaflets have significantly higher values of protein, fat, carbohydrate, ascorbic acid, dry matter, hydrogen cyanide ($p<0.05$) and have significantly lower values of moisture and crude fibre ($p<0.05$) than bipinnate leaflets. However, there was no significant difference in the values of ash and oxalate (Tables 1, 3 and 4). For anti-nutritional composition, oxalate value was very small (0.02, 0.02 mg/100 g), phytate was not detected while toxicity level was very low as small quantity of hydrogen cyanide was obtained (0.12, 0.53 mg/100 g) in both bipinnate and unipinnate leaflets respectively. Unipinnate leaflets also have significantly higher values of Ca, Fe, Zn, Mg, Mn, Cu ($p<0.05$) and significantly lower value of Pb ($p<0.05$) than bipinnate leaflets. There was no significant difference ($p>0.05$) in the values of K, Na, Cr, Cd, Ni while As was not detected in the two types of the leaflets (Table 2). The result also showed that grasshoppers were visiting and feeding regularly on the two types of the leaflets of *N. exaltata*.

DISCUSSION

This study revealed that *N. exaltata* is a perennial plant; it is available in dry and wet seasons and capable of accumulating heavy biomass that can accommodate herbivores interaction. The leaflet was very high in moisture and ascorbic acid contents but very low in fat, ash and crude fibre contents in both leaflets. The carbohydrate contents of *N. exaltata* is high in both bipinnate (5.98 %) and unipinnate (7.08 %) leaflets (Table 1), therefore, it can serve as a source of carbohydrate in the diet of ruminants and this is similar to the findings of Oloyede *et al.* (2008). *N. exaltata* is a better source of dietary ascorbic acid (52.80 & 69.96 mg / 100 g) than *N. bisserata* with 4.79 mg/100 g and *Ceratopteris cornuta* (P. Beauv.) Lepr. (27.27 & 27.27 mg/100 g).

The protein levels in *N. exaltata* is higher than in *N. biserrata* (6.13%), *Ceratopteris cornuta* (5.28 & 4.22 g/100 g) fertile and sterile fronds. The anti-nutritional content was very low compared with some other ferns as oxalate (0.02, 0.02 mg/100 g) content of *N. exaltata* was much lower than that of *N. biserrata* (0.75 mg/100 g) and *Ceratopteris cornuta* (1.38 & 0.88 mg/100 g) fertile and sterile leaflets respectively. Its cyanide content (0.12, 0.53 mg/100 g) was also lower than *Ceratopteris cornuta* with (0.86 & 1.16 mg/100 g) contents for the fertile and sterile fronds respectively (Oloyede *et al*., 2010). The anti-nutrient and toxicity levels of the two types of leaflets in this plant fall within the safe and acceptable limits as recommended by WHO (Munro and Bassir, 1969) in which the threshold of oxalate toxicity in man is 2.5 mg/ 100 g and cyanide is 2.0-4.0 mg / 100 g in sheep. Hence, this fern can be used to enhance animal production. These findings in this study were similar to the reports on *N. biserrata* which shows that its nutrient value is high, insect feeds on its leaflets Oloyede *et al*. (2008) and it is useful as fodder for feeding West African dwarf goats (Babayemi *et al*., 2006). Invertebrates such as small snails feed regularly on the leaflets of *N. furcans* Oloyede *et al.* (2012) and insects visit and feed on the leaflets of *N. exaltata* as well. These results are however different from the report of Eastop (1973) and Hendrix (1977) who reported that ferns were difficult plants for herbivores to exploit. Phytic acid and arsenium were not detected probably due to the quantity of the materials used. The concentrations of mineral reported in this study suggested that both types of leaflets in this fern are very rich in some of these

Table 1: Proximate Compositions, Dry matter and Ascorbic acid of the Leaflets of *N. exaltata*

Substances %	Bipinnate Leaflets ± S.E	Unipinnate Leaflets ± S.E
Protein	9.45±0.21	12.47±0.08*
Moisture	82.65±0.32	78.50±0.30*
Fat	0.47±0.40	0.54±0.41 ns
Ash	0.87±0.11	0.93±0.02 ns
Crude Fibre	0.57±0.04	0.47±0.05 ns
Carbohydrate	5.98±0.16	7.08±0.18*
Dry matter g/100 g	17.53±0.51	21.50±0.72*
Ascorbic acid mg/100 g	52.80±0.89	69.96±0.01*

Note: *represent significant difference at 0.05 probability level; ns represent not significantly different at 0.05 probability level

Table 2: List of Mineral Elements of the Leaflets of the two Fronds of *N.exaltata*

Elements (ppm)	Bipinnate Leaflets	Unipinnate Leaflets
K	0.71±0.001	0.71±0.001 ns
Na	0.23±0.000	0.24±0.000 ns
Ca	0.16±0.001	0.29±0.002*
Fe	5.99±0.007	6.68±0.022*
Zn	1.04±0.010	1.07±0.005*
Cd	0.03±0.000	0.04±0.000 ns
Pb	0.30±0.005	0.15±0.005*
Mg	3.89±0.015	5.60±0.023*
Mn	0.27±0.002	0.61±0.001*
Cu	0.06±0.001	0.10±0.001*
Cr	0.02±0.001	0.03±0.001 ns
Ni	0.01±0.001	0.02±0.001 ns
As	ND	ND

Note: *represent significant difference at 0.05 probability level; ns represent not significantly different at 0.05 probability level

Table 3: Some Anti-nutrient substances in the Leaflets of the two Fronds of *N.exaltata*

Substances (mg/100 g)	Bipinnate Leaflets	Unipinnate Leaflets
Oxalate	0.02±0.001	0.02±0.001 ns
Phytate	ND	ND

Note: ns represent no significant difference at 0.05 probability level

Table 4: Levels of Toxicants in the Leaflets of the two Fronds of *N.exaltata*

Toxicants (mg/100 g)	Bipinnate Leaflets	Unipinnate Leaflets
Hydrogen cyande	0.12±0.005	0.53±0.005*

Note: *represent significant difference at 0.05 probability level

nutrients especially potassium, iron, sodium and calcium.

N. exaltata contains high ascorbic acid (vitamin C), carbohydrate, some minerals; little quantity of oxalate and cyanide contents; therefore, it is beneficial to ruminants in the tropics. The result of the nutrient composition from this work shows that *N. exaltata* is nutritious. This was however in contrast to Auerback and Hendrix (1980) who reported that the less underutilization of ferns by herbivores was attributed to poor nutritional compositions. The presence of insects (*Chorthippus brunneus*, Common field grasshopper) and ants that visit *N. exaltata* regularly and feed on the leaflets may be due to glabrous and beautifully coloured leaflets; high nutritional values and low toxic contents. *N. exaltata* contains appreciable and reasonable amounts of ascorbic acid and nutrients which play important roles in metabolic activities in the body. These results are in agreement with the findings of Tapiero *et al.* (2002) who reported that eating green vegetables regularly can provide high amount of minerals especially ascorbic acid that protects the body against oxidative stress. *N. exaltata* is therefore a better source of nutrients for herbivores and can be used to fortify animal feeds. Statistically, there was a significant difference in most of the mineral elements in the two leaflets but zinc and ash were not significantly different at ($p<0.05$).

CONCLUSION

In conclusion, the oxalate and cyanide contents of the two fronds were significantly low and their inclusion in ruminant feeds is not likely to cause any health hazard to them. The two types of leaflets are potential good sources of dietary energy, protein, carbohydrate, vitamin C and mineral elements for ruminant animals. Due to the overall nutritional qualities of the two types of leaflets, there are a lot of advantages in their inclusions as cheap sources of food energy in the livestock diet by local farmers in rural dwellings. Since it was established in this work that unipinnate leaflets have significantly higher values of protein, fat, carbohydrate, ascorbic acid, Na, Ca, Fe, Zn, Cd, Mg, Mn, Cu and significantly lower value of Pb and oxalate hence, unipinnate leaflet of *N. exaltata* is more nutritious than bipinnate leaflets.

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