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Nutritional and Phytochemical Investigation of *Boerhaavia diffusa* L. an Edible Wild Vegetable in South West Nigeria

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Abstract **Original Research Article**

The leaves and roots of *Boerhaavia diffusa* L. were analysed for phytochemical, proximate and mineral compositions. The results of the qualitative phytochemical screening revealed the presence of alkaloids, saponins, phlobatanins, cardiac glycosides and reducing sugar in both the leaves and roots of the plant. More so, Tannins and phenols were found in the roots while flavonoids and terpenoids were found in the leaves. The results of the quantitative composition of the phytochemicals showed that the roots and leaves of the vegetable were rich sources of alkaloids (19.91±0.74% and 28.57±0.30%), saponins (66.65±0.83% and 45.91±0.67%) and cardiac glycosides (45.13± 0.13% and 56.29± 0.25%). Proximate results showed that the roots and leaves of the wild vegetable had low moisture content (14.14±0.23% and 14.34±0.02%), ash content (5.32± 0.04% and 4.09 ±0.42%), crude protein (4.80± 0.05% and 2.42 ± 0.06 %), very low crude fat (0.40±0.10% and 0.45 ± 0.59%), high crude fiber (29.65 ±0.00% and 30.44± 0.42%) and moderate Carbohydrate (45.65± 0.09% and 48.29 ± 0.09%) respectively. The vegetable was rich in Na, K, Ca, Mg and Fe with moderate amount of Cu, Zn, and Mn while Pb and Ni (heavy metals) were not detected. This wild vegetable investigated contained bioactive phytochemicals that might support its excellent therapeutic uses in the treatment and prevention of diseases. The vegetable could also serve as energy and mineral rich food supplement.

Keywords: *Boerhaavia diffusa*, Phytochemical, Therapeutic, Wild vegetable, Food supplement.

INTRODUCTION

Since the time immemorial, human beings have used medicinal remedies from the herbs, flowers, seeds and other flora in their environment. Medicinal plants are natural products derived from plants for the treatment of various ailments. These plants have found a diverse use in the society as they have potentials for curative and medicinal uses. Demand for medicinal plants has been increasing due to the great efficiency of herbal remedies in Nigeria most especially the south west part is notable for their biodiversity of plants. These plants whose fruits, seeds, shoot, leaves, nuts and tubers, serve as an indispensable constituents of peoples diet supplying their body with protein, carbohydrate, essential minerals and vitamins. Traditionally, some of these wild plants are not only sources of dietary nutrients in food but also have high medicinal values [1]. Vegetables play an important role in human nutrition. They are known for their essential biochemical and nutritional importance as they contained appreciable amount of protein, fat, fiber, carbohydrate, vitamins, macro and micro- elements [2].

Despite the fact that vegetables, most especially the wild edible vegetables serve as an indispensable constituents of human diet providing the body with minerals, vitamins, fiber in addition to essential amino acid and energy [3], a large percentage of these vegetables are under-exploited or even unexploited or neglected.

Studies have revealed that vegetarians are less prone to diseases, live longer, healthier and more productive lives with stronger immunity [4, 5]. In spite of the nutritional contribution and the health promoting and protecting a attributes of these edible wild vegetables, there has been very little concerted effort towards exploiting them for improving nutritional status of the local populace. Scientific data on the nutrients and chemical of these wild edible vegetables are scanty and people do not have adequate information on whether these known wild vegetables are beneficial or not. Hence, this study was carried out to evaluate the phytochemical compositions and nutritional potential of

B. diffusa in order to provide useful information for its uses/ utilization.

Boerhaavia diffusa belongs to a wild species of leafy vegetables that are relatively underutilized and neglected [6]. *B. diffusa* belongs to the family Nyctaginaceae and is regarded as an important medicinal plant commonly used in Ayurveda medicines and other traditional medicines in many parts of the world. It is a diffusely branched, pubescent or glaborous, prostrate herbs, abundantly occurring as a weed. Edible parts of *B. diffusa* are leaves, seeds and roots. The leaves are cooked and eaten as vegetable. Seeds are used as tonic expectorant, scabies, scorpion sting, blood purifier as well as muscular pain [7]. Its roots are used in treating jaundice, internal inflammations, asthma and piles [8]. *B. diffusa* root extracts equally strengthens, tones and balances the liver (hepatotonic) [9]. The plant had been reported by several authors to be very effective as laxative expectorant, diuretic [10], antidote to rat, rat bite poison and in rabies [11]. In Nigeria, *B. diffusa* is used for asthma, boils, convulsions, epilepsy, fever, guinea worms and expectorant and laxative [12].

MATERIALS AND METHODS

Collection and sample preparation

Fresh leaves and roots of *B. diffusa* were obtained from an uncultivated farmland in Ado- Ekiti, Ekiti State, Nigeria. The town is located at Latitude of 7˚ 40'N and Longitude 5˚ 15'E in the tropical region of South-western, Nigeria. The sample was identified and authenticated in the herbarium of the Department of Plant Science and Biotechnology, Ekiti State University Ado-Ekiti. The leaves and roots were air dried at room temperature (25-30^{0}C) for two weeks. The air dried plant samples were pulverized and stored in air tight containers for analysis.

Determination of Phytochemical Constituents

The qualitative phytochemical screening of the samples was carried out as prescribed by Harbone [13] and Sofowora [14]. The samples were screened for alkaloids, tannins, saponins, phenols, flavonoids, terpenoids, cardiac glycosides, phlobatanins and reducing sugar. Quantitative phytochemical determination was carried out using the method of AOAC [15].

Proximate analysis

Proximate analysis was carried out according to the procedure of Association of Official Analytical Chemist AOAC [16] to determine the moisture content, carbohydrate, crude protein, crude fat, crude fiber and ash content of the samples. Moisture content was determined by heating 5 g of the sample in a crucible inside an oven at temperature of 105 ^{0}C to a constant weight. Total ash was determined by weighing 5 g of each sample in a crucible and ignited in a muffle furnace at 550 ^{0}C for 6 hr, cooled and reweighed [16]. Crude protein was determined by multiplying the nitrogen content of the sample by 6.25 [15]. Crude fat was determined by digesting about 5 g of the sample with H_2SO_4 and NaOH. The residue was placed into a crucible in a muffle furnace at about 550 ^{0}C for 5 hr.

Carbohydrate was determined according to Onwuka [17]. Available carbohydrate was calculated as follows:
% Available carbohydrate = 100 – (% moisture + % ash + % protein + % fiber)

Determination of Mineral Content

For mineral determination, wet digestions of the two samples were carried out according to the method of Alpodogan *et al.*, [18]. Zinc, Manganese, Magnesium and Iron were determined by Atomic Absorption Spectrophotometer while Sodium, Potassium and Calcium were measured through flame photometer.

RESULTS

The qualitative phytochemical composition of *B. diffusa* leaves and roots showed that tannins and phenols were absent in the leaves but were present in the roots. Likewise flavonoids and terpenoids were absent in the roots but present in the leaves. Steroids were absent both in the leaves and roots. Other phytochemicals, saponins, alkaloids, phlobatanins, cardiac glycosides and reducing sugar were both present in the roots and leaves of *B. diffusa* (Table 1). The quantitative phytochemical composition of the roots and leaves of *B. diffusa* revealed higher saponins content in the root (66.65%) than the leaf (45.91%). Reducing sugar (8.29%), Cardiac glycosides (56.29%) and alkaloids (28.57%) were higher in the leaves than the roots. Total phenols (33.22%) and tannins (32.34%) were present in the roots and absent in the leaves (Table 2).

The proximate composition of *B. diffusa* of roots and leaves showed that the roots of *B. diffusa* were richer in protein (4.80%) and ash (5.23%) than the leaves. Higher concentration of carbohydrates (48.29%) and crude fiber (30.44%) were recorded in the leaves of *B. diffusa* (Table 3).

The mineral composition of the roots and leaves of *B. diffusa* showed that the plant is rich in macro elements, Magnesium (104.32mg/100g), Potassium (88.07mg/100g), Calcium (109.72mg/100g) and as well as micro elements. The concentration of Iron in the roots (57.46mg/100g) and leaves (73.96mg/100g) were very high. However, toxic elements, Pb and Ni were not detected in the plant samples (Table 4).

Table 1: Phytochemical screening of the roots and leaves of *B. diffusa*.

Parameters	Leaves	Roots
Tannins	-	+
Phenols	-	+
Saponins	+	+
Phlobatanins	+	+
Alkaloids	+	+
Steroids	–	–
Reducing Sugar	+	+
Flavonoids	+	-
Terpenoids	+	-
Cardiac glycosides	+	+

Key: + indicates present, - indicates absent

Table 2: Quantitative phytochemical composition of the root and leaves of *B. diffusa*

Parameters (%)	Roots	Leaves
Saponins	66.65±0.83	45.91±0.67
Alkaloids	19.91±0.74	28.57±0.30
Tannins	32.34±0.20	0.00±0.00
Total phenols	33.22±0.39	0.00±0.00
Flavonoids	0.00±0.00	0.00±0.00
Reducing Sugar	6.77±0.08	8.29±0.10
Cardiac glycosides	45.13± 0.13	56.29±0.25

Table 3: Proximate composition of the roots and leaves of *B. diffusa.*

Parameters (%)	Roots	Leaves
Moisture content	14.44±0.23	14.34±0.02
Crude protein	4.80±0.05	2.42±0.06
Crude fat	0.40± 0.10	0.45±0.59
Ash content	5.32±0.04	4.09±0.42
Crude fiber	29.65±0.00	30.44±0.42
Carbohydrate	45.63±0.09	48.29±0.09

Table 4: Mineral composition of the root and leaf of *b. diffusa.*

Parameters(mg/100g)	Roots	Leaves
Sodium	132.49±0.69	119.81±0.54
Potassium	72.93±0.30	88.07±0.31
Calcium	103.11±0.35	109.72±0.48
Magnesium	95.97±0.21	104.32±0.23
Zinc	13.60±0.32	11.35± 0.15
Manganese	1.02±0.04	1.65±0.25
Copper	1.18±0.10	0.83±0.09
Iron	57.46±0.33	73.96±0.27
Lead	0.00±0.00	0.00±0.00
Nickel	0.00±0.00	0.00±0.00

DISCUSSION

The medicinal values of higher plants are due to the presence of several bioactive phytochemical constituents that produce definite physiological actions on human and animal body. These secondary metabolites in medicinal plants form the basis of modern prescription drug [19]. The results of this finding revealed that both the leaves and roots of *B. diffusa* contained saponins, alkaloids, phlobatanins, cardiac glycosides and reducing sugar. Tannins and phenols were present in the root and absent in the leaves while flavonoids and terpenoids were present in the leaves but absent in the roots. Quantitatively, saponins, alkaloids, tannins and cardiac glycosides content in the roots and leaves were high. Kadota *et al.*, [20] and Lami *et al.*, [21] reported that *B. diffusa* contained phytochemical constituents such as flavonoids, alkaloids, sterols and triterpenoids.

The finding from this study is similar to the previous work of Pereira *et al.*, [22] who carried out a metabolite profiling and biological study in *B. diffusa* roots and leaves. The results of the study differs from the work of Chuahan *et al.*, [23] who reported the presence

of tannins and total phenols in the leaves of *B. diffusa*. High concentration of these bioactive chemicals has been reported to be hazardous to the body [24]. This fear may be allayed as these multiple constituents usually act synergistically. Alkaloids are one of the most efficient therapeutic bioactive substances in plants. Abigail *et al.*, [25] reported that flavonoids shown antibacterial, anti-inflammatory, anti-allegic and antiviral activity. Phenols are considered to have anti-microbial properties which in turn could make the plant effective in the treatment of typhoid fever and bacterial infections [26]. Saponins serve as natural antibiotics which help the body to fight infections and microbial invasions. They also help in lowering cholesterol and knock out some tumour cells [27]. Antidiabetic activities of flavonoids and phenolic compounds have been reported by several authors [28, 29].Tannins have astringent properties, hastens the healing of wounds and inflamed mucous membrane [30]. Terpenoids has been reported to be effective against bacterial such as *Staphylococcus aureus* [31].

Several researchers have documented pharmacological and biological activities of *B. diffusa* roots and leaves. Analgestic and anti-inflammatory properties of *B. diffusa* might be due to the presence of alkaloids. Mungantiwar *et al.*, [32] reported immune modulatory effect of the alkaloidal fraction from the roots of *B. diffusa*. The previous experimental report of Seth *et al* [33] corroborated the acclaimed herbal use of this vegetable and antiviral activities of this wild vegetable have been documented by Sushil *et al.,* [33]; Pari and Satheesh [35]; Lohani *et al*., [36]; Girish and Satish [37]; Pereira *et al.,* [22]. Several health benefits that have been attributed to *B. diffusa* might be as a result of their rich biologically active chemical substances.

The moisture content of the roots and leaves of *B. diffusa* in the study was high compared to 3.77% reported for *Kedrosis africana* [38] but comparatively low to that reported for some wild leafy vegetables like *Carpesium cernuum* (85.18%), *Tricytric pillosa* (90.08%), *Leea sambucina* (81.34%) and *Neptunia olearacea* (85.47%) [39]. Low moisture content gives plant materials long shelf life and reduce microbial spoilage. Ash content obtained from the roots and leaves of *B. diffusa* in this work were low when compared to 11.17% and 16.40% record for *Brassica olearacea* and *Telferia occidentalis* respectively [12]. The plant could be regarded as fiber vegetable and perhaps its high fiber contents can contribute significantly to dietary fiber intakes. The results of this work corroborated with the findings of Chauhan *et al.,* [23] who reported high fiber content in the root of *B. diffusa*. Fiber lowers the body cholesterol level thereby reduce the risks of cardiovascular diseases [40] as well as aid digestion [41].

The crude fat content in this finding compared favourably to the fat content range of 0.21-0.45% of some leafy vegetables in Nigeria [42] but lower than 1.45-4.76% reported for some wild vegetables consumed in Bangladesh [43]. Crude fat content in this study is in tandem with the general observation that leafy vegetables are low lipid containing foods that plays an important role in avoiding obesity [44]. The low crude fat in *B. diffusa* could make the plant useful for people on low lipid diet. The crude protein values of the root and leaf of *B. diffusa* compared well to the values reported for some common vegetables like cabbage (1.8%), Lettuce (2.1%), Broad beans leaves (4.5) and Spinnach (2.0%) [39]. However, the values were low when compared to the values obtained for *Adansonia digitata* (18.08%), *Amaranthus hybridus* (13.25%), *Hibiscus sabdariffa* (14.27%) and *Ceiba pentandra* (15.20%) respectively [45]. The carbohydrate contents were relatively higher than 22.20% and 17.14% reported for roots and leaves of *B. diffusa* investigated by [23]. These values were however lower than those reported for *Dryopteris filix-* mass (52.78%), *Cochorus capsularis* (60.21%) and *Nymphaea stellate* (76.34%) [43]. Carbohydrate provides energy for the body. The vegetable could be regarded as energy rich vegetable.

The result of valuable mineral elements obtained for *B. diffusa* showed that this underutilized vegetable was rich in Na, K, Ca, Mg and Fe. Na and K play an important role in the transport of metabolites in the human body. K helps in regulating heartbeat, neurotransmission and water balance of the body [46]. Ca is an important macro-nutrient for the growth and maintenance of teeth, bone muscle and heart function [47]. The results obtained for Iron (Fe) in the plant samples were cheering. The Fe contents of *B. diffusa* studied were higher than recommended dietary allowance for males (1.37mg/ day) and females (2.94mg/day) [48]. Fe is important in the diet for the formation of haemoglobin, normal functioning of the central nervous system and in the metabolism of carbohydrate, protein and fats [49]. Thus, the investigated wild vegetable could be recommended in human diets for reducing anaemia and more importantly, pregnant women. In fact, the vegetable could contribute three times more than the RDA of 18mg/day needed by adults [50].

The Zinc content found in the roots and leaves of the wild vegetable was higher to the level reported in some wild and cultivated vegetables in India and Nigeria [39, 51]. Zn functions as a membrane stabilizer and a stimulant of the immune response. Its deficiency leads to poor growth, loss of appetite and general weakness [49]. Manganese is needed in the diet for skeletal growth and development as well as cofactor of many enzymes, protein synthesis and RNA and DNA synthesis of the human body. The Mn values reported for this study showed that *B. diffusa* could provide a good source of Mn to human diet. Cu plays an important role in the formation of haemoglobin and also in many different enzymes activities. Lead and Nickel were not detected in

the roots and leaves of the vegetable. Pb and Ni are highly toxic heavy elements that cause both acute and chronic poisoning. The absence of these elements in *B. diffusa* showed that the vegetable roots and leaves were safe for consumption.

CONCLUSION

This study revealed that *B. difussa*, a wild vegetable have the potential to provide essential nutrients needed to promote good health. The vegetable is a rich source of macro and micronutrients especially Ca, K and Fe, hence could be incorporated into diets in combating mineral deficiencies especially in rural communities. The vegetable could also be incorporated as supplement in man's diet. The rich bioactive constituents of this vegetable lend credence to its strong pharmacological activities in the management of various ailments.

Conflict of Interest: Authors declare that they do not have any conflict of interest.

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