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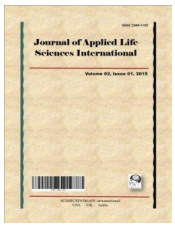
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Phytochemical Constituents, Proximate Composition and Mineral Analysis of Aqueous and Ethanolic Stem Bark, Seed Extracts and Plant Parts of *Moringa oleifera*

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Authors' contributions

This work was carried out in collaboration between all authors. Author ODT designed the study. Authors OOE and OAA wrote the protocol, performed statistical analysis and wrote the first draft of the manuscript. Author OVT managed the literature searches. All authors read and approved the final manuscript without any conflict of interest.

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ABSTRACT

Moringa oleifera is a small size multipurpose tree of approximately 5 to 10 m in height which is cultivated all over the world. The phytochemical constituents of aqueous and ethanolic stem bark and seed extracts of *Moringa oleifera* were assessed and compared. The mineral and proximate analyses were carried out on some selected parts of the plant. The result of the qualitative phytochemical constituents showed the presence of tannins, flavonoid, alkaloids, saponins, steroids, terpenoids and cardiac glycoside in both aqueous and ethanolic extracts. Results showed the presence of iron, calcium, potassium and zinc. Proximate analysis in all the investigated plant

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parts revealed the presence of carbohydrate, protein, fat, fiber and ash with the leaves having highest percentage of protein (18.61%). The results from this study prove extensively the use of the plant in ethnomedicine and its potential for diet formulation.

Keywords: Moringa oleifera; nutritive minerals; phytochemicals; ethno-medicine.

1. INTRODUCTION

Diets for ruminants traditionally have been equipoise for energy, protein, vitamins, and minerals. Therefore, because the role of rumen must be sustained for optimal animal production, minimum amount of fiber is often specified as a given percentage of forage, however, digestibility of the fiber is seldom considered while formulating diet. Dairy and meat production in dry regions is characterized with low quality and shortage of fodder, hence, its complexity [1]. The increase in human population is greatly accelerating requirements for food, which subsequently threatens environmental conservation and increasing the gap between the availability and accessibility of resources as well as meeting of human necessities, hence, the depletion of natural resources. Plant scientists are therefore exploring and investigating good-quality fodders that can fulfill the life necessities of both human beings and livestock in an economical way without degrading natural resources. Over the last few years, under-utilized crops and trees have captured the attention of plant scientists, nutritionists, and growers. Research on some plants showed that *Moringa oleifera* (*M. oliefera*) is one of the promising plants which could add to increased intake of some essential nutrients and health-promoting phytochemicals [2]. Phytochemicals have been shown to be ubiquitous in fruits, vegetables, legumes (beans and peas), and grains we eat, hence, its inclusion in diet. *Moringa oleifera*, also called Horseradish tree, is a pan-tropical species that is known as benzolive, drumstick tree, kelor, marango, saijhan, and sajna [3]. It is the most commonly cultivated species of a monogeneric family that is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. Today, it is naturalized in many locations in the tropics and is widely cultivated in most parts of the world [3]. It is one of the recently discovered vegetable with wide acceptability in Nigeria [4]. It is widely grown and cultivated in the northern part of Nigeria where it is locally called Zogeli (among the Hausa speaking people). *M. oleifera* can be grown in a variety of soil conditions with preference to well-drained sandy or loamy soil that is slightly alkaline [5,6]. It is known as one of the world's most resourceful trees, as almost every part of the tree is beneficial to health [7,8]. The leaves, especially young shoots, are eaten as greens, in salads, in vegetable curries, and as pickles. Such can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value. The leaves are considered to offer great potential for those who are nutritionally at risk and may be regarded as a protein and calcium supplement [9].

In ethnomedicine, *Moringa oleifera* leaves have been used by local traditional healers to cure various ailments ranging from gastric discomfort, stomach ulcers, diarrhea, dysentery to skin infections. In certain case of diabetes, *Moringa* can also be used to ensure the stability of sugar levels, hence, stabilize arterial tension [10,11]. Other properties reported on the leaves include anti-tumour, anti-pyretic, anti-epileptic, anti-inflammatory, anti-ulcer, anti-spasmodic, diuretic, anti-hypertensive and antioxidant properties [10,12]. In order to contribute to the growing body of knowledge on this subject, the present study analyzed the proximate, mineral and phytochemical constituents of different parts of *Moringa oleifera* in the formulation of diet for ruminants.

2. MATERIALS AND METHODS

2.1 Collection and Identification of Plant Material

Young plant parts of *Moringa oleifera* were collected from a Moringa tree growing at a farmland in the suburbs of Ilorin, kwara state Nigeria and was identified and authenticated in the Department of Plant biology, Kwara State University, Malete, Nigeria and a voucher specimen was deposited accordingly at the herbarium of the Department.

2.2 Preparation of Plant Extracts

2.2.1 Drying process

The fresh plant parts of *Moringa oleifera* were harvested, washed and dried for seven days under shed, at room temperature to avoid loss of active compounds. The dried plant samples were

ground to powder using a pulverized laboratory mechanical grinder (Christy and Norris limited, machine type 8) and the fine powders obtained were stored in an air-tight bottle until further use.

2.2.2 Extraction process

2.2.2.1 Aqueous extract

The extraction process used was hot-water method (decoction) following the procedure of Edeoga et al. [12]. 50 g of the powdered sample were soaked in 500 ml of distilled water and boiled for about ten minutes. After boiling, the sample was double-filtered using cheese cloth and collected in a conical flask and allowed to cool. The filtrate was dried in hot-air oven at temperature of 70°C.

2.2.2.2 Ethanolic extract

50 g of the powdered sample were soaked in 500 ml of absolute ethanol and allowed to stand for 24 hours. The mixture was stirred occasionally. After 24 hours, the sample was double filtered using cheese cloth and collected in a conical flask. The filtrate was dried in hot-air oven at temperature of 45°C Edeoga et al. [12].

2.3 Phytochemical, Mineral and Proximate Analyses

Qualitative phytochemical analysis of the Moringa stem bark extracts (aqueous and ethanolic) were carried out for the presence of flavonoids, anthraquinone, alkaloids, saponins, steroids, terpenoids, cardiac glycoside, anthocyanin, tannins and carotenoids using the standard procedures as described by Edeoga et al. [12] and Oluduro [13]. The quantitative mineral and proximate compositions of the stem bark, seed cake, seed husk, fruit pod, leaf and stalk extracts were assessed following the methods of Oluduro [13].

3. RESULTS AND DISCUSSION

The phytochemical screening of Moringa oliefera seed and stem bak extracts, presented in Tables 1 and 2, revealed the presence of tannins, flavonoid, alkaloids, saponins, steroids, terpenoids and cardiac glycoside in both the aqueous and ethanolic extracts. These phytochemicals are biologically active and can be responsible for their ethnomedicinal uses. The mechanisms through which these secondary metabolites exert their activities differ. Intestinal disorders such as diarrhea and dysentery have been treated with herbs that have tannins as their main components [14]. Another secondary metabolite observed in the seed and stem bark extracts of *Moringa oliefera* was alkaloid. Alkaloids have analgesic effects [15] and have been clinically used [16]. Alkaloids have been acclaimed for their antimicrobial activities, especially against gram negative bacteria [17]. Other secondary metabolites present in *Moringa oliefera* whose nutritional activities have been documented are flavonoids and saponins [18]. Flavonoids is known to inhibit adipogenesis [19] and to induce apoptosis in mouse pre-adipocytes [20,21].

Table 1. Qualitative phytochemical screening of stem bark extracts of aqueous and ethanolic extracts of *Moringa oleifera*

Phytochemical	Aqeous extract	Ethanolic extract
Saponins	+	+
Tannins	+	+
Reducing sugars	-	-
Glycosides	+	+
Alkaloids	+	+
Volatile oils	-	-
Steroids	+	+
Terpenoids	+	+
Flavonoids	+	+

Table 2. Qualitative phytochemical screening of seed extracts of aqueous and ethanolic extracts of *Moringa oleifera*

Phytochemical	Aqeous extract	Ethanolic extract
Saponins	+	+
Tannins	+	+
Reducing sugars	-	-
Glycosides	+	+
Volatile oils	-	-
Steroids	+	+
Terpenoids	+	+
Flavonoids	+	+
Alkaloids	+	+

As presented in Tables 3 to 8, all the investigated plant parts contain considerable nutrients and minerals. Of all the investigated plant parts, the leaves contain highest composition of protein (18.61%). This is comparatively higher than protein content of *Momordica foecide* (4.6%) leaves consumed in Nigeria and Swaziland [22,23], but lower than those of *Ipomoea batatas* (24.85%), *Amaranthus candatus* (20.5%), *Piper guineeses* (29.78%) and *Talinium triangulare*

(31.0%), [24,25]. Pearson [26] documented that plant food that provides more than 12% of its calorific value from protein is considered good source of protein. Therefore, *Moringa oliefera* leaves meet this requirement. This is also in agreement with daily protein requirement for adults, children, pregnant and lactating mothers [27].

Table 3a. Quantitative proximate compositions of *Moringa oliefera* stem bark

Nutrient	Composition (%)
Protein	1.33
Moisture	2.36
Fat	0.75
Ash	2.41
Crude fibre	4.87
Carbohydrate	88.28
Dry Matter	97.64

Table 3b. Quantitative mineral compositions of *Moringa oliefera* stem bark

Minerals	Composition (g/kg)
Iron	18.35
Zinc	49.50
Calcium	1.65
Potassium	15.24

Table 4a. Quantitative proximate composition of *Moringa oliefera* seed cake

Nutrient	Composition (%)
Protein	11.35
Moisture	8.47
Fat	2.83
Ash	2.43
Crude fibre	2.29
Carbohydrate	72.64
Dry matter	91.53

Table 4b. Quantitative mineral compositions of *Moringa oliefera* seed cake

Minerals	Composition (g/kg)
Iron	11.58
Zinc	……..
Calcium	0.20
Potassium	23.02

The carbohydrate content of *Moringa oliefera* in the investigated parts ranges from 64.41% to 89.86% (Tables 3-8). This is comparable to the reported values for *Corchorustridens* (75.0%) and sweet potatoes leave (82.8%) [28]. However, significantly higher than reported values for *Amaranthus cruentus,* (29.41%), *Celosia argentea* (32.84%) and *Corchorus olitorius* (31.34%) [23,29]. The recommended carbohydrate dietary allowance values for children, adults, pregnant and lactating mothers are 130, 130, 175 and 210 g respectively [27]. The investigated parts of *Moringa oliefera* plant showed that they are poor source of lipid. The crude oil contents ranging from 0.55 -2.87% are low compared to reported values (8.3 - 27.0%) in some vegetables consumed in West Africa [30] [31]. Investigated parts of the plant has energy values of 64.41-89.86% (Tables 3-8). The low level of fat in the investigated plant justifies that this plant is good for health. Vegetables are rich sources of fiber, which reduces the body cholesterol level, therefore lessening the risk of cardiovascular diseases. The nutritive metals basically calcium, iron, zinc and potassium were determined in the vegetables. The concentrations of these minerals are in different range. Calcium (0.2-2.25 g/kg), iron (10.95-58.5 g/kg), zinc (27.50 -106.5 g/kg) and potassium (11.68-23.02 g/kg) (Tables 3-8).

Table 5a. Quantitative proximate composition of *Moringa oliefera* seed husk

Nutrient	Composition (%)
Protein	2.51
Moisture	2.50
Fat	0.55
Ash	2.39
Crude Fibre	2.19
Carbohydrate	89.86
Dry Matter	97.50

Table 5b. Quantitative mineral compositions of *Moringa oliefera* seed husk

Minerals	Composition (g/kg)
Iron	58.50
Zinc	106.50
Calcium	1.196
Potassium	11.68

Table 6a. Quantitative proximate composition of *Moringa oliefera* fruit pod

Nutrient	Composition (%)
Protein	1.41
Moisture	2.31
Fat	0.67
Ash	2.35
Crude fibre	3.25
Carbohydrate	88.97
Dry Matter	97.69

Table 6b. Quantitative mineral compositions of *Moringa oliefera* fruit pod

Minerals	Composition (g/kg)
Iron	45.50
Zinc	83.00
Calcium	0.687
Potassium	21.03

Table 7a. Quantitative proximate composition of *Moringa oliefera* leaf

Nutrient	Composition (%)
Protein	18.61
Moisture	8.43
Fat	2.87
Ash	2.37
Crude fibre	3.31
Carbohydrate	64.41
Dry Matter	91.57

Table 7b. Quantitative mineral compositions of *Moringa oliefera* leaf

Minerals	Composition (g/kg)
Iron	12.81
Zinc	27.50
Calcium	0.80
Potassium	16.09

Table 8a. Quantitative proximate composition of *Moringa oliefera* leaf stalk

Nutrient	Composition (%)
Protein	4.54
Moisture	2.35
Fat	0.72
Ash	3.22
Crude fibre	4.48
Carbohydrate	84.69
Dry Matter	97.67

Table 8b. Quantitative mineral compositions of *Moringa oliefera* leaf stalk

Minerals	Composition (g/kg)
Iron	10.95
Zinc	51.00
Calcium	2.25
Potassium	15.45

Calcium has been shown to be characterized for growth and maintenance of bones, teeth and muscles [32,33], hence, this plant could avail echt sources of calcium. Minerals are important for acid and water balance in the body as well as other body functions. Calcium therefore constitutes larger percentage in the structure of the body and in the bones. Iron is an essential component of hemoglobin which invariably aid transportation of oxygen in the body. This vegetable can therefore make-up the daily requirements of Ca, Fe and Zn which have reported by FAO/WHO [34] at (260 mg/day), (0.425 mg/g) and zinc (0.099 mg/g) respectively [35,36].

4. CONCLUSION

From this study it is revealed that *Moringa oliefera* plant is nutritious and provides the body with sufficient quantity of nutrients required for normal functioning and reproduction. This study also reveals diversity of nutrient compositions in the researched plant. Vegetables often contain low level of fat, hence, a staple food for obese people. They are also rich in fiber, a feature that enhances them to decrease the concentration of high cholesterol level in body. The mineral content while comparing with recommended dietary allowance, it reveals that the investigated plant is a good source of calcium, iron and zinc. Moreover, this present study has confirmed its effectiveness by traditional users in ethno medicine. However, its potentials in synthetic drug formulation should be harnessed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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