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Original Article

THE PROXIMATE AND MINERAL COMPOSITION OF THE LEAVES AND STEMS OF *Balanites aegyptiaca*

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ABSTRACT

The leaves and stems of *Balanites aegyptiaca* were analyzed for the proximate and mineral contents using standard methods of food analysis. The results revealed that the plant leaves and stems contained: moisture (14.20 ± 0.06%; 11.23 ± 0.02%), ash (12.02 ± 0.04%; 10.01 ± 0.01%), crude protein (11.60 ± 0.02%, 10.31 ± 0.03%), crude lipid (7.56 ± 0.03, 9.23 ± 0.03%), crude fibre (13.60 ± 0.12%, 12.10 ± 0.03%) and available carbohydrate (55.22 ± 0.03%; 58.35 ± 0.12%) respectively. High energy values of 312.12 ± 0.56 kcal/100g for the leaves and 337.09 ± 0.15 kcal/100g for the stems were recorded. Their respective mineral contents were found to be: K(1164.8 ± 0.02; 1032.40 ± 0.01mg/100g), Na (805.60 ± 0.01; 196.80 ± 0.02 mg/100g), Ca(416.40 ± 0.12; 26.12 ± 0.01 mg/100g), P (850.37 ± 0.01; 7.06 ± 0.03 mg/100g), Mg(23.6 ± 0.14; 13.6 ± 0.11 mg/100g), Cu (1.20 ± 0.01; 5.2 ± 0.12 mg/100g), Fe (32.14 ± 0.04;24.4 ± 0.01 mg/100g), Mn (15.35 ± 0.02; 11.12 ± 0.13 mg/100g) and Zn (20.23 ± 0.15; 6.4 ± 0.03 mg/100g) respectively for the leaves and stems. When compared with their respective recommended dietary allowances (RDA) and nutrient densities (ND), the plant leaves and stems were good sources of K, Na, Cu, Fe, Mn, and Zn while the leaves were a rich source of Ca.

Key words: *Balanites aegyptiaca*, Leaves, Stems, Recommended Dietary Allowance, Nutrient Density.

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INTRODUCTION

Balanites aegyptiaca is a the species classified either as a member of the *Zygophyllacea* or the *Balanitacea*. It is commonly called the desert date in English and in Arabic, it is known as Lalob, Hidjihi and Heglig. In Swahili, it is known as Mduguyu and in Amharic, it is called Bedena (Wikipedia, 2010). The vernacular names include Aduwaa (Hausa) and Aduwa (Nupe) (Abudullahi *et al*., 2003). The species is native to Africa and parts of the Middle East, where it can be found in many kinds of habitat, tolerating a wide variety of soil types from sand to heavy clay; and climate moisture levels, from arid to sub-humid. It is relatively tolerant of flooding,

livestock activity, and wildfire. The yellow, single seeded fruits are edible but bitter. Many parts of the plants are used as famine foods in Africa; the leaves are eaten raw or cooked. The oily seeds is boiled to make it less bitter and coated mixed with sorghum and the flowers can be eaten. The tree is considered valuable in arid regions because it produces fruits even in dry season, and such fruits can be fermented for alcoholic beverages. *Balanites aegyptiaca* seeds contain 30-40% oil commonly used for cooking oil. The seed cake remaining after extraction is commonly used as animal fodder in Africa. The fruit is mixed into porridge and eaten by nursing mothers; and the oil is useful in the treatment of headache and to improve lactation.

Information available on the nutritional composition of *Balanites aegyptiaca* is scanty. Therefore, the objective of the present study is to provide information on the proximate and mineral contents of the leaves and stems of *Balanites aegyptiaca* with the hope that it would be incorporated into the food basket of the country.

MATERIALS AND METHODS

Sample Collection and Treatment

Samples of *Balanites aegyptiaca* used in this study were collected from a farm located in Wushishi town beside River Kaduna Niger State, Nigeria. The chemicals used were manufactured by M&B and BDH Chemicals of England.

Prior to analysis, the leaves were separated from the stems and washed with distilled water. The residual moisture was evaporated in open air at room temperature. Thereafter, the materials were wrapped in large paper envelopes and oven dried at 60^0C until two consecutive constant weights were obtained.

The dried leaves and stems were then ground in porcelain mortar, sieved through 2mm mesh sieve and stored in plastic containers (Idris *et al.* 2009). The powdered samples were used for both the proximate and mineral analysis. Moisture contents were, however, evaluated using fresh specimen of the leaves and stems.

Proximate Analysis

The moisture contents of the leaves and stems were determined by drying 5g of the material (in triplicates) in Gallenkamp oven at 105^0C until two consecutive constant weights were attained (AOAC, 1990), Ash content was determined according to the method described by Ceirwyn (1995) which involved dry-ashing in Gallenkamp muffle furnace at 600^0C until grayish white ash product was obtained. Crude protein content was calculated by multiplying the value obtained from Kjeldahl's nitrogen by a protein factor of 5.3, a factor recommended for vegetable analysis (Bernice and Merril, 1975). Crude lipid was quantified by the method described by AOAC (1990) using the Soxhlet apparatus and n-hexane as a solvent. Crude fiber was determined by acid–base digestion with 1.25% H_2SO_4 (w/v) and 1.25% NaOH (w/v) solutions. Available carbohydrate was calculated by subtracting i.e, total sum of crude protein, crude lipid, crude fibre and ash from 100% dry matter (AOAC, 1990).

The sample calorific (energy) value was determined using the following equation: Energy (Calorific) value (kcal/100g) = (crude lipid × 9) + (crude protein × 4) + (available carbohydrate × 4) after Asibey – Berko and Taiye, (1999).

Samples Preparation

Six grammes of the powdered sample was weighed into a crucible and gently heated over a Bunsen burner until it was charred. The charred sample with the crucible was transferred into a Gallenkamp muffle Furnace at about 600^0C and the content was ashed until a grayish white ash was obtained. It was cooled first at room temperature and then in a desiccators thereafter. 5cm^3 of conc. HCl was added and heated for 5 minutes on a hot plate in a fume cupboard. The mixture was then transferred into a beaker and the crucible washed several times with distilled water. The mixture was made up to 40 cm^3 and boiled for 10 minutes over a Bunsen burner. This mixture was then cooled, filtered into 100 cm^3 volumetric flask and distilled water was used to rinse the beaker into the volumetric flask and the solution made up to the volume (Ceirwyn, 1995). The solutions were prepared in triplicates.

Mineral Quantification

Sodium (Na) and Potassium (K) contents of the plant materials were analysed by flame atomic emission spectrophotometer with NaCl and KCl as standards. Phosphorous (P) was determined with Jenway 6100 spectrophotometer at 420nm using vanadium phosphomolybdate (vanadate) calorimetric method with KH_2PO_4 as the standard (Ceirwyn, 1995). The concentrations of Calcium (Ca), Magnesium (Mg), Copper (Cu), Iron (Fe), Manganese (Mn) and Zinc (Zn) in the solutions were determined using computer control Atomic Absorption Spectrometer model AAS 969 (AOAC, 1990).

Nutrient Density (ND)

The nutrient density is the index of nutritional quality used to evaluate nutritional significance of mineral elements. The sample nutrient densities were calculated using the equation reported by Hassan *et al.* (2008):

$$ND\ (\%) = \frac{\frac{Np}{Ep} \times 100}{Nr/Er}$$

Where Np = nutrient concentration (mineral element in the food)

Ep= energy supplied by food

Nr= recommended daily intake of nutrient

Er= recommended energy intake (3000 kcal/day) for an adult male recommended by WHO/FAO (Cole, 1980)

$$RDA(\%) = \frac{\text{Concentration of the element}}{RDA} \times 100$$

RDA= recommended dietary allowance (NRC, 1989).

Data Analysis

Data were generated in triplicates and the mean, as well as, standard deviation determined according to Steel and Torrie (1980)

RESULTS AND DISCUSSION

Proximate Composition

The results of proximate compositions of the leaves and stem of *Balanites aegyptiaca* given in Table 1, showed that the leaves and stem had moisture content of 14.20 ± 0.06% and 11.23 ± 0.02% wet weight, respectively. These values were low compared to the 7.40 ± 2.40 % and 90.93 ± 3.13% reported or the leaves and stem of *Gynandropsis mandra* (Hassan *et al.*, 2005).

n the other hand, the ash content which is i index of mineral contents was higher in e leaves (12.02 ± 0.04%) than the stems 0.00 ± 0.01%). The ash content in the aves fall within the range of 9.20±1.5 to 28.00±1.1% reported in green leafy vegetables consumed in Sokoto Nigeria (Ladan *et al.*, 1996), and 2.60 ± 0.25% obtained in the leaves of *Gynandropsis gynandra* (Hassan *et al.*, 2005). According to Lintas (1992), vegetables vary in chemical composition even within one variety, depending on the species and conditions of growth. The stems also recorded high ash content compared with the 1.87 ± 0.32% indicated in the stem of *Gynandropsis gynandra* (Hassan *et al.*, 2005) and 0.84 ± 1.30% found in sweet potatoes stems (Ishida *et al.*, 2000). This analysis indicated that the leaves of *Balanites aegyptiaca* could be a better source of mineral elements than the stem.

ble 1: Proximate compositions of the leaves and stems of *Balanites aegyptiaca*

rameters	Concentration (% Dry Weight)	
	Leaves	Stems
isture[a]	14.20 ± 0.06	11.23± 0.02
ı	12.02 ± 0.04	10.01 ± 0.01
ıde protein	11.60 ± 0.02	10.31 ± 0.03
ıde lipid	7.56 ± 0.03	9.23 ± 0.02
ıde fiber	13.60± 0.12	12.10 ± 0.03
ailable Carbohydrate	55.22± 0.03	58.35 ± 0.12
rgy (caloric) Value in (kcal/100g)	312.12±0.56	337.09± 0.15

e data are mean values ± standard deviation (SD) of three replicates.
ılues are expressed as % wet weight.

e crude protein content (11.60±0.02%) in e leaves was higher than 10.31±0.03% of e stems. The protein content of the leaves *Balanites_aegyptiaca* was high compared the 10% indicated in the leaves of *Senna usfolia* (Faruq *et al.*, 2002) and 8% found weet potato leaves (Asibey – Berko and e, 1999). The stem protein content was when compared to 12.47± 0.37% of the s of *Gynandropsis gynandra* (Hassan *et* 2005).

The stems crude lipid contents of 9.23±0.02% were higher than 7.56±0.03% of the leaves. The sample lipid content was higher than the 5.00±0.04% and 5.00±0.12% reported for the leaves and stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005), 3.83% obtained in *Cassia obtusfolia* leaves (Agbo, 2004) and 1.85% to 4.75% indicated in some edible green leafy vegetables of Southern Indian (Gupta *et al.*, 2005). This finding revealed that the leaves and stems of *Balanites aegyptiaca* are poor

sources of plant lipid, which is in agreement with general observation that leafy vegetables are low lipid containing foods, thus, advantageous healthwise in avoiding obesity (Lintas, 1992).

The crude fibre content in both leaves (13.60± 0.12%) and stems (12.10±0.03%) was low compared to the 22.10±2.12% and 23.36±3.31% in the leaves and stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005). According to Aletor and Adeogun (1995), the major drawbacks to the use of vegetable in human nutrition is their high fiber content which invariabily causes intestinal irritation and lowers nutrient bioavailability hence large quantities of plant vegetables have to be consumed to provide adequate levels of nutrients. However, fiber, its intake can reduce serum cholesterol level, hypertension, diabetes, breast cancer and constipation (Ishida *et al.*, 2000; Ramula and Rao, 2003). Thus the leaves and stem of *Balanites aegyptiaca* could be a valuable source of dietary fiber.

The available carbohydrate was high for both the leaves (55.22±0.03%) and the stems (58.35±0.12%) samples. The leaves value is higher than 20% obtained in *Senna obtusfolia* (Faruq *et al.*, 2002), the 23.7% in *Amaranthus incurvatus* leaves (Asibey – Berko and Taiye, 1999) and comparable to the 40.7 – 52.5% of fluted pumpkin leaves (Ladeji *et al.* 1995; Akwaowo *et al.*, 2000). On the other hand, the stem value was higher than the 57.30 ±0.00 % found in the stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005).

According to Lintas (1992), vegetables, on wet weight basis, have low energy values between 10 and 50 kcal/100g. However, the values of 312.12±0.56 and 337.09±0.25 kcal/100g obtained in *Balanites aegyptiaca* leaves and stems, respectively are higher than the 248.8 – 307.1 kcal/100g reported for some Nigerian green leafy vegetables (*Isong et al.*, 1999) and 280.32 and 276.84 kcal/100g showed for the leaves and stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005).

Mineral contents

The result of mineral concentration of the leaves and stems of *Balanites aegyptiaca* is presented in Table 2. The potassium contents in the leaves and stems of *Balanites aegyptiaca* were 1164.80+0.02 and 1032.40+0.01mg/100g dry matter respectively. These values were higher than the 114.38±0.75 and 164.00±0.47mg/100g dry matter reported for the leaves and stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005). The samples sodium concentrations of 805.60 ± 0.01mg/100g for the leaves and 196.80 ± 0.02 mg/100g for the stems were higher than 30.50 ±0.50 and 47.25 ± 0.21 mg/100g recorded for the leaves and stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005). The result also indicated that K and Na concentrations were higher in the leaves than in the stems of the samples. Yoshimura *et al.* (1991) reported that the increase in K/Na ratio in diets might be important for the prevention of hypertension since K depresses while Na enhances blood pressure. Tomori and Obijole (2000), indicated that a K/Na ratio of 3 to 4 is considered the most adequate for the normal retention of protein during growth. The K/Na ratio in the stems of *Balanites aegyptiaca* was 5.25 while that of the leaves was 1.45 which implied that the K/Na ratio in the stems was above the range reported by Tomori and Obijole (2000).

Table 2: Mineral Compositions of the leaves and stems of *Balanites aegyptiaca*

Mineral Elements	Concentrations (mg/100) dry matter.	
	Leaves	Stems
K	1164.80 ±0.02	1032.40 ± 0.01
Na	805.60 ±0.01	196.80 ± 0.02
Ca	416.40 ±0.12	26.12 ± 0.01
P	85.37 ±0.01	7.06 ± 0.03
Mg	23.60 ±0.14	13.60 ± 0.11
Cu	1.20 ± 0.01	5.20 ± 0.12
Fe	32.14 ±0.04	24.40 ± 0.01
Mn	15.35 ±0.02	11.12 ± 0.13
Zn	20.23 ±0.15	6.40 ± 0.03
K/Na	1.45	5.25
Ca/P	4.88	3.70

The Data are Mean Values ± Standard deviation (SD) of Three Replicates.

Calcium and Phosphorus are both associated with the growth and maintenance of bones, teeth and muscles (Dosunmu, 1997; Turan *et al.*, 2003). The calcium concentration of the leaves (416.40±0.12 mg/100g) was higher than 26.12 ± 0.01 mg/100g for the stems. This calcium level in the leaves was higher than 57.03±0.12 mg/100g reported for the leaves of *Abelmosclus esculentus* (Idris *et al.*, 2009), the 33 and 38 mg/100g respectively reported for lettuce and sickle pods (Faruk *et al.*, 2002). The calcium content for the stems was lower than the 411.77±0.03 mg/100g obtained for the stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005).

The phosphorus content in the leaves of *Balanites aegyptiaca*(85.37±0.02 mg/100g) was lower compared to the 166-640 mg/100g found in some green leafy vegetables consumed in Sokoto (Ladan *et al.*, 1996) and 260 mg/100g indicated for sickle pod (*Cassia obtusfolia*)leaves (Agbo, 2004). The stems phosphorus content was also lower than the 121.3±2.14 mg/100g shown in *Gynandropsis gynandra* stems (Hassan *et al.*, 2005). According to Guil-Guerrero *et al.* (1998), for good Ca-P intestinal absorption, the Ca/P ratio must be close to unity. The Ca/P ratio for the leaves (4.88) and the stems (3.70) were higher in favour of calcium. Thus, *Balanites*

aegyptiaca appears to be a good source of calcium but a poor source of Phosphorus.

Magnesium is an important mineral element in connection with circulatory diseases and calcium metabolism in bones (Ishida *et al.*, 2000). *Balanites aegyptiaca* contained 23.60 ± 0.14 mg/100g of magnesium in the leaves and 13.60 ±0.11mg/ 100g in the stems. In this study, Mg was found to be concentrated more in the leaves, as it is a component of chlorophyll (Dosunmu, 1997; Akwaowo *et al.*, 2000). The magnesium content in the leaves and the stems of this plant were lower compared to the 79-107mg/100g and 30.0-35.5mg/100g indicated in the leaves and stems of sweet potatoes (Ishida *et al.*, 2000).

Copper is an essential trace element in humans where it exists as an integral part of copper proteins, ceruloplasmin, which is concerned with the release of iron from the cells into the plasma and is involved in energy metabolism (McDonald *et al.*, 1995: Adeyeye, 2002). The copper content in both the leaves and stems of *Balanites aegyptiaca* were 1.20± 0.01mg/100g and 5.20±0.12mg/100g respectively. The value of copper in the leaves sample fell within the range of 1.2-1.8mg/100g indicated in some leafy vegetables found in Yola, Nigeria (Baminas *et al.*, 1998) while the stems value was higher than the 3.43±0.02 mg/100g shown in the stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005).

Iron is an essential trace element for haemoglobin formation, normal functioning of the central nervous system and in the oxidation of carbohydrates, proteins and fats (Adeyeye and Otikiti, 1999). From the results, it was shown that these samples are rich in iron with a higher concentration of 32.14±0.04 mg/100g in the leaves than the 24.40±0.01 mg/100g in the stems. The samples iron content was higher than the 27.00±0.01mg/100g and 20.96±0.01 mg/100g indicated for leaves and stems of *Gynandropsis gynandra* (Hassan *et al.*, 2005). The results further revealed that the leaves and stems of *Balanites aegyptiaca* are good sources of iron compared to its recommended dietary allowance (RDA) of 10mg/day for adults and children(7-10 years), 13mg/day for pregnant and lactating mothers and 15mg/day for female(NRC, 1989).The leaves of *Balanites aegyptiaca* may therefore be a good source of iron in

Manganese is another micro-element essential for human nutrition. It acts as activator of many enzymes (McDonald *et al.*, 1995). The concentration of manganese in the leaves samples was 15.35±0.02

mg/100g while for the stem it was 11.12±0.13mg/100g. The Mn content in the leaves was within the range of 15-115mg/100g reported for some leafy vegetables found in Cross Rivers state, Nigeria (Ifon and Bassir, 1979). This finding revealed that the leaves and stems of *Balanites aegyptiaca* are good sources of manganese compared to the RDA for Mn which is 2-5mg/day for adult male and female, pregnant and lactating mothers, 2-3mg/day for children (7-19 years) (NRC, 1989).

Zinc, which is involved in the normal functioning of the immune system, was found to have concentrations of 20.23±0.15 and 6.40±0.03 mg/100g in the leaves and stems of *Balanites aegyptiaca* respectively. The sample leaves value was higher than the 10.30±0.00mg/100g recorded in *Solanum americanum* leaves (Hassan and Umar, 2008) while the stem content was lower compared to the 27.83±0.38mg/100g in the stems of *Gynandopsis gynandra* (Hassan *et al.*, 2005). Compared to the RDA for zinc (10mg/day for children 7-10 years, 12mg/day for adult male, 15mg/day for adult female and 19mg/day for pregnant and lactating mothers) (NRC, 1989) it is shown that the leaves of *Balanites aegyptiaca* is a good source of this mineral element.

The contribution of the leaves and stems of *Balanites aegyptiaca* to the dietary intake of essential elements was evaluated as described by Hassan *et al.*(2005) and presented in Table 3. The leaves and stems were rich sources of Iron and Manganese; the leaves were rich sources of Sodium and Zinc while the stems were rich sources of Copper. The leaves and stems were moderate sources of Potassium; the leaves were moderate sources of Calcium and Copper while the stems were moderate sources of Sodium and Zinc. The leaves and stems contained low amounts of Phosphorus and Magnesium while the stems contained very low amount of Calcium when compared with their respective recommended dietary allowances. This indicated that the leaves and the stems supplement other dietary sources of Iron, Manganese, Copper, Zinc, Potassium and Sodium while the leaves supplement for Calcium.

Table 3: Contribution of the samples to dietary intakes and the nutrient densities of some of their essential elements.

Mineral Elements	RDA (mg)	Contribution to RDA (%)		ND (%).	
		Leaves	Stems	Leaves	Stems
K	2000	58	52	560	459
Na	500	161	39	1549	350
Ca	1200	35	2	334	19
P	1200	7	1	68	5
Mg	350	7	4	65	35
Cu	1.5-3	40-80	173-347	384-769	1543-3085
Fe	10-15	214-321	163-244	3059-3089	1448-2172
Mn	2-5	307-768	222-556	2951-7377	1979-4948
Zn	12-19	106-169	34-53	1023-1620	300-475

RDA = Recommended dietary allowance **ND = Nutrient density**

Food materials having nutrient density of 100%, supply the nutrient needed in the same proportion as the calorie needed. Those with ND less than 100% will not provide the proportionate amount of the nutrient. The leaves and the stems of *Balanites aegyptiaca* were rich sources of Potassium, Sodium, Copper, Iron, Manganese and Zinc while the leaves were rich sources of Calcium as a result of their higher nutrient densities (i.e. greater than 100). Nutrient density of 100% or more indicates that the food material, if consumed in sufficient quantities, contributes substantially to the intake of that particular element (Amaro-Lopez *et al.*, 1998).

CONCLUSION

The results of the proximate and mineral analysis revealed that the leaves and the stems of *Balanites aegyptiaca* are good sources of plant protein, crude fibre, carbohydrate and energy. The moderate amount of crude protein (10.31 and 11.6%) showed that *Balanites aegyptiaca* is a useful source of protein that could alleviate malnutrition among some sections of the populace. These findings also indicated that the leaves and stems of this plant are good sources of minerals such as K, Na, Cu, Fe, Mn and Zn when compared to their respective RDA and ND. This thus suggests that the leaves and stems of this plant when consumed in sufficient amount, will contribute immensely to meeting the nutritional requirements for normal body growth and protection.

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