



Proximate and Elemental Analysis of Desert Date (*Balanites aegyptiaca*) Leaves: A Rich Medicinal Plant of Public Health Value

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Abstract

Balanites aegyptiaca, commonly known as Desert Date, is a valuable tree species found in arid and semi-arid regions, traditionally used for its nutritional and medicinal properties. This study evaluated the proximate and elemental composition of Desert Date leaves using AOAC methods. The desert date leaves were purchased at Jimeta modern market and the experiment was carried out at Science Laboratory Technology Laboratory. Proximate analysis revealed that the leaves contain low moisture content (8.50%) and high dry matter (91.50%), with substantial crude protein (28.42%), crude fiber (12.81%), and carbohydrate (44.86%) levels, but low crude fat (1.91%). Elemental analysis identified iron (5.224 mg/100g), calcium (5.714 mg/100g), and potassium (1.550 mg/100g), all below the recommended dietary allowances, along with trace amounts of zinc (0.290 mg/100g) and sodium (0.292 mg/100g). These findings suggest that Desert Date leaves could serve as a nutritional supplement, particularly for protein and fiber, though their mineral contribution is limited.

Keywords: *Balanites aegyptiaca*, Proximate, Analysis, Desert Date, Nutrition, Elemental analysis

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1. Introduction

African countries are blessed with different species of plants with medicinal, nutritional and socio-economic importance. Among these plants is the *Balanites aegyptiaca* Linn., a tree that is more valued for its fruits and kernels. Popularly known as desert date, *Balanites aegyptiaca* is an all-important multipurpose tree plant found in almost all African countries. The desert date fruit and its kernel are widely used in many ways in Nigeria and other African countries especially during the dry season and drought periods (Nasser *et al.*, 2016). The kernel of this plant is traditionally also used as remedy to certain ailments including intestinal worm infection, syphilis, jaundice, malaria, dysentery, constipation, hemorrhoid and epilepsy among others. The stem of the desert date is used for shade, mulch, windbreak, gum, poles, timber, firewood, charcoal, tool handle, utensils, food and fodder. It has also been used as an oral antidiabetic drug especially in the Egyptian folk medicine, and for ages it has been used in the treatment of several disorders and diseases (Charity *et al.*, 2018).

Balanites aegyptiaca is a desert plant commonly called Desert date, Soapberry tree, Egyptian balsam or Thorn tree. It is a

member of the family *Zygophyllaceae*. It is known by different vernacular names in Nigeria and other parts of the world. In Nigeria the Hausa name is 'Aduwa' while Fulani call it 'Tanni'. In Swahili, it is called 'mchunju', the Arabs refer to it as 'Heglig'. Indians and Amharic in Ethiopia call it 'Hingot' and 'Bedena' respectively (Tesfaye, 2015).

B. aegyptiaca is widely distributed but neglected tree of the arid zones of Africa and South Asia (Wakawa, 2018). It is highly resistant to sandstorms and heat waves and grows with minimal available moisture and are available in different habitats. *B. aegyptiaca* can grow on different soil types i.e. from sand to heavy clay. The plant is a deep-rooted, evergreen or semi-deciduous, multi-branched, spiny tree which grows up to 12m in height. The colour of the stem bark of the old plant ranges from brownish to greyish and abysmally fissured. The shoots bear long and thick green thorns when young but later become yellow. The thorn can grow up to 8 cm long which are soft at first and later become woody. The leaves are dark green or grey-green, fleshy and succulent with two firm coriaceous leaflets spirally arranged on the shoots. The leaflets are long, up 2.5-6.0cm; grainy surface,

with fine hairs when young while the fruit is a long, slender drupe, ranges from 2.5 to 7cm long and 1.5 to 4cm in diameter. Fresh fruits are always green and tomentose but later becomes yellow and glabrous as it becomes older (Eldin, 2016).

This all-important tree is used for food and fodder in almost all African countries and the South Asia. The protein content of the fruit of this plant is believed to be superior than that in guava, mango, banana and papaya, with the fleshy fruit containing high carbohydrates, some essential minerals, steroidal saponins, vitamins A and C for human (Al-Thobaiti and Abu-Zeid 2018). The kernel produces high quality edible oil with large number of medicinal properties. This oil is regarded as vegetable oil because it is obtained from a plant source, with the main importance of vegetable oils being the food values they possess. The edible seed kernel of this important plant is rich in oil, protein, minerals among others (Eldin, 2016). *Balanites aegyptiaca* is a perennial plant native to arid and semi-arid regions of Africa and the Middle East. It belongs to the family *Zygophyllaceae* and is known for its economic, medicinal, and ecological importance. The leaves of *Balanites aegyptiaca* have been traditionally used for various purposes, including fodder for livestock, traditional medicine, and as a potential source of bioactive compounds (Eldin, 2016). The stem bark of *Balanites aegyptiaca* is used as a fish poison but it is not poisonous to man, the stem bark and the fruits are used in Morocco, Nigeria and Senegal as a laxative or purgative for colic and stomach aches, the edible bitter-sweet pulp is used as food or confectionary, and laxative as well as for the treatment of constipation. The leaves are used to make soup by some tribes in Nigeria while in Chad the fresh twigs are burned to produce smoke to keep insect away (Nkunya *et al.*, 2019). The plant is indigenous to all arid zones, south of the Sahara, which extends southward to Malawi in the Rift Valley, and to the Middle East (Nkunya *et al.*, 2019).

2. Materials and Methods

2.1 Study Area

The sample for this study was purchased at Jimeta modern market Yola north which is located in the Northern Guinea Savannah ecological zone of Nigeria within latitude 9°10'N and longitude 12°35'E of the equator. The altitude is 185.5m and mean annual rainfall ranges between 900-1100mm for 150-160 days, usually from May to October. It has a minimum and maximum temperature 20°C to 45°C and relative humidity of 55 to 65% (Babalola *et al.*, 2021). The sample was then transported to the laboratory unit of the Science Laboratory Technology Department of Modibbo Adama University, Yola for analysis.

2.2 Materials

Some of the Materials/Reagents used include:

Materials/Reagents

Digestion flask	Volumetric flask
Pipette	Whatman Filter paper
Soxhlet Extractor,	Digestion flask
Crucible	Desiccator,
Cotton wool,	Trioxonitrate (v) acid (HNO ₃)
Hydrochloric acid (HCl)	Petroleum ether
De-ionised water	Sodium hydroxide (NaOH)
Ammonium sulphate	tetraoxosulphate (vi) acid (H ₂ SO ₄)

Atomic Absorption Spectrophotometer Buck Scientific 210 was used.

2.3 Sample Collection of *Balanites aegyptiaca* Leaf

The leaf sample of *Balanites aegyptiaca* was collected from Yola North local government area of Adamawa state. The sample was first treated with clean distilled water to remove all the necessary dirt from the sample. The sample was then carried to the laboratory in a clean polythene bags for preparation.

Balanites aegyptiaca leaf samples were thoroughly cleaned to remove dirt, debris, and any extraneous matter. This was done by gently washing the leaves under running water and patting them dry with clean paper towels. Cleaned *Balanites aegyptiaca* leaf samples were air-dried at room temperature to remove excess moisture. This step was crucial for preventing microbial growth and ensuring the stability of the samples during storage and analysis. Dried *Balanites aegyptiaca* leaf sample was ground into a fine powder using a laboratory mortar and pestle. This increased the surface area of the samples, facilitating homogenization and extraction of nutrients and minerals. The ground *Balanites aegyptiaca* leaves powder were thoroughly mixed to ensure uniformity and consistency across samples. This step is essential for obtaining representative aliquots for analysis. Sub-sampled *Balanites aegyptiaca* leaf sample was stored in clean, air-tight containers to prevent contamination and moisture absorption (Smith & White, 2021). Sample was labelled with relevant information such as sample ID, date of collection, and sampling location (Brown, 2020).

2.4 Digestion Method

In digestion, 0.5 g of Desert date leaves sample that had been ground was used, accurately weighed and placed into a beaker with 15 cm³ of HCl, H₂SO₄ mixture and HNO₃ in the ratio of 3:1:1 mixed together in a volume of 9 cm³, 3cm³ and 3cm³ respectively, were added into the flask. The flask was placed in a digestion block inside a fume hood at the temperature of about 45°C for 25 minutes, and then the temperature was increased to 50°C for five minutes to ensure the complete digestion. The flask was removed and the digest filtered and the volume made up to 50 cm³ using deionized water (AOAC, 2020).

2.5 Elemental Analysis

The prepared sample was submitted for elemental analysis at the Central Laboratory of Modibbo Adama University for the determination of the elements: calcium, potassium, sodium, and zinc. Below are the procedures followed for the elemental analysis in the study:

2.5.1 Determination of Calcium Content

The calcium content in *Balanites aegyptiaca* leaf sample was quantified using standard analytical procedures to assess their nutritional value (AOAC, 2020). Initially, dried and finely ground *Balanites aegyptiaca* leaf sample was digested using acid digestion methods to release calcium ions into solution (Smith & Johnson, 2018). Acid digestion involved treating the sample with hydrochloric acid or nitric acid to dissolve organic matter and release calcium. Following the digestion, the calcium concentration in the sample solution was determined using Atomic Absorption Spectroscopy (AAS) (Garcia *et al.*, 2019). AAS method provides precise measurements of calcium ions in the sample solution based on their absorption or emission

characteristics. The calcium content was expressed as milligrams of calcium per gram of dried sample, providing insights into the mineral composition and potential dietary significance of *Balanites aegyptiaca* leaves (Jones & Smith, 2021).

$$\text{Calcium content (mg/g)} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times \frac{\text{concentration of standard}}{\text{weight of sample}}$$

2.5.2 Determination of Iron Content

The prepared digest was analysed for iron content using Atomic Absorption Spectroscopy (AAS). AAS method provides precise measurements of iron in the sample solution based on their absorption or emission characteristics. The iron

content was expressed as milligrams of iron per gram of dried sample, providing insights into the mineral composition and potential dietary significance of *Balanites aegyptiaca* leaves. The intensity of the absorption of the sample was compared to the calibration curve to determine the iron concentration:

$$\text{Iron content (mg/g)} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times \frac{\text{concentration of standard}}{\text{weight of sample}}$$

2.5.3 Determination of Sodium Content

The sodium content in *Balanites aegyptiaca* leaf sample was determined using standard analytical methods to evaluate their nutritional composition using Atomic Absorption Spectroscopy (AAS) (AOAC, 2020). This method provides accurate measurements of sodium ions in the sample solution

based on their absorption or emission characteristics. The sodium content was expressed as milligrams of sodium per gram of dried sample, providing insights into the mineral composition and potential dietary significance of *Balanites aegyptiaca* leaves (Jones & Smith, 2021).

$$\text{Sodium content (mg/g)} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times \frac{\text{concentration of standard}}{\text{weight of sample}}$$

2.5.4 Determination of Zinc Content

The zinc content in *Balanites aegyptiaca* leaf sample was assessed using standard analytical methods to evaluate their nutritional profile (AOAC, 2016). Following the pre-treatment stage (digestion), the zinc concentration in the sample solution was determined using Atomic Absorption Spectroscopy (AAS) (Garcia *et al.*, 2019). This method provides accurate

measurements of zinc ions in the sample solution based on their absorption or emission characteristics. The zinc content was expressed as milligrams of zinc per gram of dried sample, providing insights into the mineral composition and potential dietary significance of *Balanites aegyptiaca* leaves (Jones & Smith, 2021).

$$\text{Zinc content (mg/g)} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times \frac{\text{concentration of standard}}{\text{weight of sample}}$$

2.6 Proximate Analysis

Proximate composition of the sample was determined using the AOAC methods (AOAC, 2020).

2.6.1 Moisture Content

The moisture content of the all samples was measured as described by AOAC method (AOAC 2020). Crucibles was thoroughly washed and dried in an oven at 100°C for 30 minutes and allowed to cool inside desiccators. After cooling, it was weighed and recorded as W_1 . Then, 2.0 g of the finely ground Desert date sample was put into crucibles and weighed as W_2 . Thereafter, the sample plus the crucible was placed inside the oven and dried at 100°C for 4 hours; allowed to cool and weighed at the same temperature for 30 minutes until a constant weight was obtained as recorded as W_3 . Then, the moisture content of the Desert Date leave sample was calculated:

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where,

W_1 = Initial weight of empty crucible,

W_2 = Weight of crucible + sample before drying

W_3 = Final weight of crucible + sample after drying.

2.6.2 Ash Content

Total ash of the Desert date leaf samples was determined by Furnace Incineration described by AOAC Method (AOAC, 2020). Out of the finely ground dried sample, 2.0 g was weighed into porcelain crucibles and incinerated at 600°C for 6 hours in an ashing muffle furnace until ash was obtained. The ash was cool in desiccator and reweighed. Then the ash content was calculated:

$$\text{Ash content (\%)} = \frac{\text{Weight of ash}}{\text{Weight of dried sample}} \times 100$$

2.6.3 Crude Fibre

Crude fibre was determined using the method of AOAC (AOAC, 2020). Out of the desert date sample, 2.0 g was defatted with petroleum ether after which the residue was boiled under reflux for 30 min with 200 ml of 1.25 % H_2SO_4 solution. The solution was filtered through a filter paper, after filtration the samples was washed with hot water until they are no longer acidic. Then, the residue was transferred into a beaker and boiled for another 30 min with 200 ml of 1.25 % NaOH solution. The residue was then washed with hot water until they are no longer alkaline. The insoluble residue was then ashed in a furnace at 550 °C for 2 hours. The furnace was then put off and allowed to cool down. The sample was then removed and cooled in a desiccator and weighed. The crude

fibre content was then calculated as loss of weight in ashing. Weight of original sample was used as W.

$$\text{Crude fiber content (\%)} = \frac{\text{Weight of residue before ashing} - \text{weight of ash}}{\text{Weight of sample}} \times 100$$

2.6.4 Fats

The Fat content was determined as described by AOAC Method (AOAC, 2020). Clean boiling flasks (250 ml) was dried in an oven at 105°C - 110°C for about 30 min and cooled in a desiccator. Approximately 2.0 g of sample was weighed accurately into a thimble. The dried boiling flask filled with about 300 mL of petroleum ether (boiling point 40 - 60°C). The extraction thimble was plugged tightly with cotton wool. After that, the Soxhlet apparatus was assembled and allowed to refluxed for 6 hours. The thimble was removed with care and petroleum ether was collected from the top container and dried into another container. After that, the flask was dried at 105 - 110°C for 1 hour. After drying, it was cooled in desiccator and weighed. Then, % fat content in the Desert date leaf samples was calculated:

$$\text{Fat content (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

2.6.5 Determination of Crude Protein

The crude protein content of the Desert date sample was determined using the Micro Kjeldahl methods of AOAC (AOAC, 2020) which involved protein digestion, distillation and titration. **Protein Digestion:** Out of the date leaf sample, 2 g was weighed into a Kjeldahl flask, 0.8 g tablets of Kjeldahl Catalyst were added, 20 ml concentrated sulphuric acid was introduced. The whole mixture was subjected to heating in the fume cupboard. The heating was done gently at first and increased with occasional shaking till the solution turned green colour. The solution was cooled and black particles showing at the neck of the flask were washed down with distilled water. The solution was re-heated gently at first until the green colour disappeared. Then, it was cooled after which the digest was transferred into a 250 ml volumetric flask. Out of the digest, 5.0 ml was pipetted into the body of the apparatus via a small funnel aperture. The digest was washed down with distilled water followed by addition of 15 ml of 40 % NaOH solution. The digest in the condenser was steamed for 1 - 5 minutes after which enough ammonium sulphate was collected. The receiving flask was removed and the tip of the condenser washed down into the flask after which the condense water was removed. The solution in the receiving flask was titrated with 0.01M hydrochloric acid. Also, a blank sample was ran along with the sample. After titration, the % nitrogen was calculated using the formulae below:

$$\text{Nitrogen (\%)} = (V_s - V_b) \times M(\text{acid}) \times 0.01401 \times 100$$

Where, V_s = Volume (ml) of acid required to titrate sample

V_B = Volume (ml) of acid required to titrate the blank

$M(\text{acid})$ = Molarity of acid

W_t = Weight of sample (g)

Then, percentage crude protein in the sample was calculated from the Nitrogen as:

Crude protein (%) = % N x F, where, F (conversion factor), is equivalent to 6.25

2.6.6 Carbohydrate

The total percentage of carbohydrate content in the date leave sample was determined by the difference as reported by Onyeike *et al.* (1995). This method involves adding the total values of crude protein, lipid, crude fibre, moisture and ash constituents of the sample and subtracting it from 100. The value obtained was the percentage carbohydrate constituent of the sample. Thus: % carbohydrate = 100 (% moisture + % crude fibre + % protein + % lipid + % ash).

2.7 Data Analysis

All experimental data generated were analysed and interpreted using descriptive statistics such as means and standard error of mean (SEM). The mean values were subjected to multiple comparisons of Two-way Analysis of Variance at 95 % ($p < 0.05$) confidence level using Statistical Package for Social Sciences (SPSS) (version 22).

3. Results and Discussion

3.1 Proximate Composition of Desert Date (*Balanites aegyptiaca*) Leaves

The proximate composition analysis of Desert Date (*Balanites aegyptiaca*) leaves revealed varying nutritional information about the plant's leaves (Table 1). The moisture content is relatively low at 8.50 %, indicating that the leaves have a high dry matter (DM) content of 91.50 %, which makes them suitable for long-term storage and processing. The moisture content obtained in this study is similar to the one reported (2.96%) by Wakawa *et al.* (2018).

The ash content, representing the total mineral content recorded in this study is 3.50 % which is lower than the ash content of Desert Date leaves reported by Wakawa *et al.* (2018) 13%. low ash content in the Desert Date leaves include potential limitations on nutritional value.

Table 1: Proximate Composition of Desert Date (*Balanites aegyptiaca*) Leaf

Proximate Composition (%)	
Moisture content	8.50 ± 0.04
Ash content	3.50 ± 0.06
Crude fat	1.91 ± 0.23
Crude fibre	12.81 ± 0.65
Crude protein	28.42 ± 0.09
Carbohydrate	44.86 ± 0.92
NFE	53.36 ± 0.90
DM	91.50 ± 0.04

Values are expressed as mean ± standard deviation of replicate measurements (n = 3)

NFE = Nitrogen Free Extract

DM = Dry Matter

Crude fat content is low at 1.91 %, indicating that these leaves are not a significant source of dietary. The fat content of desert date reported by Wakawa *et al.* (2018) was 4.6% which was relatively higher than what was obtained in this study. Dietary fats provide essential fatty acids have been shown to have enhance the taste and acceptability of foods, slow gastric emptying and intestinal motility thereby prolonging satiety and facilitate the absorption of lipid-soluble vitamins (FAO,

2010). The leaves are rich in crude fiber, with a value of 12.81 %, which contributes to their potential as a good source of dietary fiber, aiding in digestion. Crude fiber is essential for bowel movement and helps in preventing obesity, diabetes and cancer of the colon and other ailments of the gastro-intestinal tract of man (Okaka and Okaka, 2015).

The crude protein content is significant at 28.42 %, highlighting the potential of Desert Date leaves as a protein source. Similarly, Wakawa *et al.* (2018) reported 22.95% protein content in Desert date's leaves. The high crude protein content indicates that the leaves could be an important source for protein supplement. Protein deficiency may cause growth retardation, muscles wasting, abnormal swelling of the belly and collection of fluids in the body (Karaye *et al.*, 2020).

Comparing, Wakawa *et al.* (2018) reported 44.1% the total carbohydrate content in Desert Date leaves which is similar to the carbohydrate content 44.86 % obtained in this study, which contributes to the overall energy content. The nitrogen-free extract (NFE), a measure of easily digestible carbohydrates, is 53.36 %. Thus, from the proximate composition results obtained, it suggests that Desert Date leaves could serve as a valuable nutritional supplement.

3.2. Elemental Composition of Desert Date (*Balanites aegyptiaca*) Leaves

Table 2 presents the elemental composition (mg/100g) of Desert Date (*Balanites aegyptiaca*) leaves compared with the RDA – Recommended Dietary Allowance for iron (Fe), zinc (Zn), calcium (Ca), potassium (K), and sodium (Na). Minerals and trace metals are required in humans in trace amount to maintain good health and excess of it might be toxic (Alector & Omodara, 2014). The higher content of most mineral elements found in desert date could be a reflection of its ash content.

Table 2: Elemental Composition of Desert Date (*Balanites aegyptiaca*) Leaves

Elemental Composition (mg/100g)	RDA (mg/day)
Fe 5.224 ± 0.045	8 – 18
Zn 0.290 ± 0.004	8 – 10
K 1.550 ± 0.008	2,600 – 3,400
Ca 5.714 ± 0.003	100 – 500
Na 0.292 ± 0.004	500 – 1000

Values are expressed as mean ± standard deviation of replicate measurements (n = 3)

RDA – Recommended Dietary Allowance

The iron (Fe) content in the Desert Date (*Balanites aegyptiaca*) leaves is 5.224 mg/100g, which, while falling below the recommended daily allowance (RDA) of 8-18 mg/day, can still contribute to daily dietary intake. Iron is essential for oxygen transport in the blood and energy production in the body. Given the prevalence of iron deficiency, the presence of iron in these leaves could offer supplemental benefits, especially when consumed as part of a varied diet (Oluymi *et al.*, 2016). Zinc (Zn) is present at a low concentration of 0.290 mg/100g, much lower than the RDA of 8-10 mg/day. Zinc is vital for immune function and wound healing. Despite its presence in the leaves, the low levels suggest that Desert Date leaves would not be a significant source of zinc in the diet especially

for those with higher needs, such as pregnant women and individuals with zinc deficiencies (Abitogun *et al.*, 2020).

Potassium (K) is found at 1.550 mg/100g in the leaves, which is notably below the RDA of 2,600-3,400 mg/day. Potassium plays a key role in regulating fluid balance and muscle contractions. Although Desert Date leaves contain potassium, the amount is insufficient to significantly impact daily intake. For individuals looking to increase their potassium intake, other food sources such as bananas, potatoes, and leafy greens would be more effective in meeting daily potassium needs (Makinde & Ibim, 2015).

Calcium (Ca) content in the leaves is 5.714 mg/100g, considerably lower than the RDA of 100-500 mg/day. Calcium is crucial for bone health and muscle function. The minimal amount of calcium in Desert Date leaves indicates that they are not a significant source of this mineral, and individuals would need to obtain calcium from other dietary sources (Makinde & Ibim, 2015).

The sodium (Na) content is 0.292 mg/100g, which is substantially lower than the RDA of 500-1000 mg/day. Sodium plays an important role in osmotic regulation of the body fluids and transmission of nerve impulses. The very low sodium levels in the leaves suggest that for individuals requiring higher sodium levels, these leaves would not serve as a significant source, making them more suitable for low-sodium diets (Yusuf *et al.*, 2007).

4. Conclusion

Desert Date (*Balanites aegyptiaca*) leaves have notable nutritional properties, particularly in terms of protein and fiber content, making them a potential dietary supplement. However, the elemental composition analysis revealed that while essential minerals were present, they are not in quantities sufficient to meet daily dietary needs. Consequently, while Desert Date leaves may contribute to nutritional intake, they should be complemented with other nutrient-rich foods to ensure a balanced diet, especially regarding mineral intake.

Recommendations

Based on the findings of this study, the following are recommended:

1. Given their high protein and fiber content, the leaves can be included in diets to enhance nutrition.
2. Further research should consider exploring the vitamins contents of Desert Date leaves to determine their actual nutritional profile.
3. Public awareness should be promoted to educate communities on the nutritional benefits and limitations of Desert Date leaves, encouraging their use as a supplement, particularly in regions facing protein deficiencies.
4. Further research should consider fortification or blending Desert Date leaves with other nutrient-dense foods to create balanced, nutrient-rich food products.

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