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DETERMINATION OF THE PROXIMATE AND MINERAL CONTENTS OF DESERT DATE KERNEL (*BALANITES AEGYPTIACA* LINN.) AND THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE KERNEL OIL AVAILABLE IN KANO STATE, NIGERIA

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ABSTRACT
The desert date *(Balanites aegyptiaca)* is one the most important relish trees found in many African countries. In this study the proximate and mineral compositions of the desert date kernel, as well as some of the physical and chemical properties of its oil were analyzed using standard procedures. The results of the proximate composition revealed the following mean concentrations: Moisture content 3.19%; ash content 2.89%; fat content 39.63%; crude protein content 33.75%; crude fiber content 13.06% and carbohydrate content 7.48%. And the mineral content revealed the following mean concentrations: Potassium 1.120 (mg/100g); calcium 0.390 (mg/100g); sodium 0.801 (mg/100g); magnesium 0.142 (mg/100g); iron 0.0024 (mg/100g); manganese 0.01512 (mg/100g); zinc 0.0082 (mg/100g); copper 0.00225 (mg/100g); nickel 0.00582 (mg/100g); cobalt 0.002623 (mg/100g) and chromium 0.003224 (mg/100g). While the results for the physical analysis of the kernel oil revealed the following: Color pale yellow; density g/cm^3 0.910; specific gravity 0.907; refractive index 1.458 and viscosity 19.68. And on the other hand, the results for the chemical analysis of the kernel oil revealed the following: acid value 3.06 mgKOH/g; free fatty acid 1.27; peroxide value 3.71 mEq/Kg; saponification value 198 mg/KOH/g and iodine value 98.73 100/g. All the results were compared and found to be within the FAO/WHO standards. The seeds kernel of this plant was found to be high nutritional value, while its oil can be a good source of raw material for many oil-based products.

Keywords: Proximate composition, Mineral contents, *Balanite aegyptiaca*, Kernel, Kernel oil.

INTRODUCTION

African countries are blessed with different species of plants with medicinal, nutritional and socio-economic importance. Among these plants is the *Balanite aegyptiaca* Linn., a tree that is more valued for its fruits and kernels. Popularly known as desert date, *Balanite aegyptiaca* is an all-important multipurpose tree plant found in almost all African countries (Clement *et al.,* 2011). 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 (Lockett *et al.,* 2000). The kernel of this plant is traditionally also used as remedy to certain ailments including intestinal worm infection, syphilis, jaundice, malaria, dysentery, constipation, haemorroid and epilepsy among others (Daya and Vaghasiya, 2011). The stem of the desert date is used for shade, mulch, windbreak, gum (Guinand *et al.,* 2001), poles, timber, firewood, charcoal, tool handle, utensils, food and fodder (Elseed *et al.,* 2002). It has also been used as an oral antidiabetic drug especially in the Egyptian folk medicine (Kamel 1991; Gnoula *et al.,* 2008; Nasser *et al.,* 2016), and for ages it has been used in the treatment of several disorders and diseases (Charity *et al.,* 2018).

This all-important tree is used for food and fodder in almost all African countries and the South Asia (Billore 1988; Elseed *et al.,* 2002). 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 (Obidah *et al.,* 2009) with large number of medicinal properties (Hanan *et al.,* 2009). 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 (Adebayo *et al.,* 2012). The edible seed kernel of this important plant is rich in oil, protein, minerals among others (Vonmaydell 1986; Elfeel and Warrag 2011). Oils are heterogeneous biochemical substances with the property of being insoluble in water, but soluble in organic polar solvents like chloroform, benzene, diethyl ether, etc. (Author 1995). In quality aspect, it is similar to sesame and groundnuts oils (Abu Al-Futuh, 1983; Obidah *et al.,* 2009), with the oil used as a biodiesel (Chapagain *et al.,* 2009; Gutti *et al.,* 2012; Kumawat *et al.,* 2012).

The objective of this study is to determine the proximate and mineral composition of desert date kernel *Balanites aegyptiaca*, and also to investigate the physical and chemical characteristics of the desert date kernel oil.

MATERIALS AND METHODS

Sample Collection and Preparation

The fruits of *Balanites aegyptiaca* (desert date) were purchased from Rimi market in Kano State, Nigeria and brought to the department of Biological Sciences, Yusuf Maitama Sule University, Kano, for identification by a plant taxonomist. The

plant was identified and authenticated and issued a voucher specimen number YUHAN 0058. The fruits were crushed using a steel hammer to obtain the kernels, which were then air-dried and then ground using mortar and pestle (Bayero *et al.,* 2019). The ground kernel was then packed in an air tight container and then stored in a desiccator (containing silica gel) ready for further analysis.

All the chemicals and reagents used were of analytical grade.

Extraction of the Sample

The powdered sample (50 g) was soaked in 300 ml of absolute ethanol for 72 hrs, and stored away from direct light. The supernatant was decanted and filtered using filter paper and the filtrate was evaporated to dryness, and then stored in sample bottles at room temperature to avoid any biological degradation (Bayero *et al.,* 2019).

Determination of the Proximate Composition of the Kernel

Moisture Content

The moisture content was determined according to of the Association of Official Analytical Chemists (AOAC, 2008). Here 2 g of the dried powdered sample was transferred into a pre-weighed dish. The sample was then placed into an oven at 105^{O}C until a constant weight was obtained. After drying, the sample was removed and transferred to a desiccator and cooled to room temperature before reweighing. Triplicate results were obtained for each sample and the mean value was reported to three decimal points according to the following formula:

$$Moisture\ Contents\ (\%) = \frac{W1 - W2}{W1} X\ 100\%$$

where;

W1= Sample weight before drying

W2 =Sample weight after drying.

Ash Content

The ash content of the desert date was determined according to the method described by Pearson (1981) and adopted by Ifeoma *et al.,* (2010). Here 5 g of the dried powdered sample was transferred into a pre-weighed and tarred porcelain crucible and placed into a muffle furnace (Yamato, DX-302C) at 550^{O}C until a white-gray ash was obtained. The crucible was the transferred to a desiccator were it was allowed to cool to room temperature and the reweighed. The ash content was then calculated as a percentage based on the initial weight of the sample using the following formula:

$$Ash\ Contents\ (\%) = \frac{(Weight\ of\ Crucible + Ash) - (Weight\ of\ Crucible)}{Initial\ Weight\ of\ the\ Sample}\ X\ 100\%$$

Fat Content

The fat content of the sample was determined according to the official method of AOAC (2008). Here 5 g of the dried powdered sample was transferred into an extraction thimble. The extraction thimble was then positioned into the Soxhlet attachment, with the pre-weighed round-bottomed flask containing 90 ml of petroleum ether. The flask was then fitted under the Soxhlet attachment and the whole set-up was placed on a heating mantle for 6 hours at 100^{O}C. At the end of the extraction period, the flask was disconnected from the unit and the solvent was redistilled. Later, the flask with the remaining crude petroleum ether extract was cooled to room temperature in a desiccator and then reweighed. The fat content was then calculated using the following formula:

$$Fat\ Content\ (\%) = \frac{(Weight\ of\ Flask + the\ Extract) - (Weight\ of\ Empty\ Flask)}{Initial\ Weight\ of\ the\ Sample}\ X\ 100\%$$

Crude Protein Content

The crude protein content of the dried powdered kernel of the desert date was determined by the micro-Kjeldahl method using a copper sulphate-sodium sulphate catalyst in accordance with the official method of the AOAC (2008). Here 2 g of the sample, 4 g of the Kjeldahl catalyst (Na_2SO_4) and 25 ml were transferred into a Kjeldahl digestion flask. The flask was then placed into a Kjeldahl digestion unit for about 2 hours until a colorless digest was obtained, and then the flask was left to cool down to room temperature. Distillation of ammonia was carried out into 25 m1 of 2% boric acid using 20 m1 distilled water and 70 m1 of 45% sodium hydroxide solution. Finally, the distillate was titrated with standard solution of 0.1 N HCl using 3 drops of bromocresol green as indicator, until a brown reddish color was observed. Using the same procedure, a blank test was analyzed using water instead of the test sample. The percentage nitrogen content of the sample was calculated as follows, as adopted by Gemechu *et al.,* (2015):

$$\%\ \text{Nitrogen by Weight}\ = \frac{(Vs - Vb)HCl\ consumed\ x\ N\ HCl\ x\ 1.4007}{Sample\ Weight}\ X\ 100$$

$$\text{Percentage Crude Protein} = \%\ \text{N x } 6.38$$

where:

Vs = Volume of HCl used for titration of the sample

Vb = Volume of HCl used for titration of the blank.

Crude Fiber Content

The percentage crude fiber of the desert date kernel was determined according to the official method of the AOAC (2008). Here 2 g of the dried powdered sample was placed into a conical flask containing 20 m1 of 2% H_2SO_4, and the flask was then fitted to a condenser and allowed to boil for 30 minutes. After this digestion, the flask was removed and the digest filtered under vacuum

through a proclain filter crucible, with the precipitate repeatedly rinsed with distilled boiled water followed by boiling in 20 ml 2% NaOH solution for 30 minutes under reflux condenser and the precipitate was filtered, rinsed with hot distilled water, followed by 20 m1 0f 96% ethyl alcohol and 20 ml diethyl ether. The crucible was finally dried overnight to a constant weight at a temperature of 105°C, then cooled in a desiccator, reweighed, and then ashed in a muffle furnace at a temperature of 550°C until a constant weight was obtained, and the difference in weight was considered as the crude fiber content. The percentage fiber content was calculated using the formula as reported by Francesca *et al.,* (2015).

$$Fiber\ Content\ (\%) = \frac{(Wt.of\ Cruc. + Dry\ Residue) - (Wt\ of\ Cruc. + Ignited\ Residue)}{Weight\ of\ the\ Sample}\ X\ 100\%$$

Total Carbohydrates

The total carbohydrates content of the dried powdered sample of the desert date was calculated by difference according to the following equations (as reported by Francesca *et al.,* (2015).

% Carbohydrate = 100 - (% Moisture + % Fat + % Ash + % Fiber + % Protein)

Determination of Mineral Content

Mineral content analysis of the dried powdered desert date kernel was carried out by transferring 5 g of the sample into a pre-weighed cleaned porcelain crucible and placing the crucible and its content into a muffle furnace at 550^{O}C until a white grey ash was obtained. The residue ash was then dissolved in 5 ml of HNO_3/HCl (1:2) and heated gently on a hot plate until the brown fumes disappeared and white coloration was formed. The solution on the crucible was then filtered into 100 ml volumetric flask and the volume made up to 100 ml with deionized water. The concentrations of potassium, calcium, sodium, magnesium, iron, manganese, zinc, copper, nickel, cobalt and chromium were determined using flame atomic absorption spectrophotometer (model VGP 210, Buck Scientific, USA) (Shahid *et al.,* 1999; Datti *et al.,* 2019).

Extraction and Purification of the Oil

The oil was extracted from the kernels of the desert date using the solvent extraction process, using petroleum ether as a solvent by soxhlet apparatus (Karamat *et al.,* 2003; Adejumo *et al.,* 2013; Ratna *et al.,* 2014). For purification, the oil was taken in a separating funnel along with water (100 ml), ether (200 ml) and saturated sodium chloride the content was well shaken and then allowed to stand. The aqueous layer was then discarded and the process was repeated three times with organic layer. Finally the ethereal extract was taken in a conical flask and then dried over 20 g anhydrous sodium sulfate, and was evaporated at a temperature of 40°C to get the purified oil (Karamat *et al.,* 2003; Ratna *et al.,* 2014).

Physical Characteristics of the Oil

Color of Oil

The color of the extracted oil from the desert date kernel was observed visually as reported by Ogala *et al.,* (2018).

Determination of Density and Specific Gravity of the Oil

The density of the desert date oil was determined using pre-washed, dried and labeled density bottles. The density bottled was then filled up to the volume mark with the oil sample, and the weight of the density bottle with the oil was determined. The density bottled was also filled up to the volume mark with the water, and the weight of the density bottle with the water was determined (Myles 2001; Brosk 2014). The density and the specific gravity of the oil were calculated using the formulae:

$$Density = \frac{W2 - W1}{V}$$

$$Specific\ Gravity = \frac{W2 - W1}{W3 - W1}$$

where:

W1 = Weight of Empty Density Bottle

W2 = Weight of Density Bottle + Oil

W3 = Weight of Density Bottle + Water

V = Volume of Oil.

Refractive Index of the Oil

The refractive index of the oil was determined using Abbe-60 refractometer (NYRL 3-Leica Mark, Leica Inc., Buffalo, New York) as described by AOAC (2008).

Viscosity of the Oil

The viscosity of the oil sample was investigation using the Ostwald-U-tube viscometer according to AOAC (2008). The viscometer was first suspended in a constant temperature water bath so that the capillary was vertical. The instrument was filled with the oil to the mark at the top of the lower reservoir with the aid of a pipette inserted in the side arm in such a way that the tube wall above the mark was not wetted. The instrument was then left to stand for 3 minutes before reading in order to equilibrate the sample temperature with that of the instrument (35°C). By means of pressure on the respective arm of the tube, the oil moved into the other arm so that the meniscus was above the mark at the top of upper reservoir. Finally, the liquid was allowed to flow freely through the tube and the time required for the meniscus to pass from the mark above the upper reservoir to that at the bottom of the upper reserve was recorded.

Chemical Characteristics of *B. aegyptiaca* Kernel oil

Acid Value of the Oil

Here 2 g of the test sample was transferred into a conical flask, and then 50 cm^3 petroleum ether added and gently mixed. Ethanol (50 cm^3) was then added into the mixture and titrated with 0.1 M KOH to pink colour (AOAC, 2008). The Acid value was calculated using the formula:

$$Acid\ Value\ (mg\ KOH/g) = \frac{Titre\ Value\ x\ Normality\ x\ 56.1}{Weight\ of\ Sample}$$

$$\%\ Free\ Fatty\ Acid = \frac{Titre\ Value\ x\ 28.2\ x\ Normality}{Weight\ of\ Sample}$$

$$1\ cm^3\ of\ 1\ M\ KOH = 56.1\ mg\ of\ KOH$$

Peroxide Value of the Oil

The peroxide value (PV) of desert date kernel oil was determined according to the procedure reported by Wail *et al.,* (1995) and adopted by Mohamed and Mohammed (2018), where 1 g of the test sample was transferred into 250 ml conical flask, then 30 ml of a glacial acetic acid/chloroform solution (ratio 3:2) was added, and the flask was gently shaken until the sample was dissolved, and then 0.5 ml of saturated potassium iodide was added. The solution was one again gently shaken for 1 minute, and 30 ml of distilled water was added followed by 0.5 ml of 1% starch solution. The content of the flask was later titrated with 0.1 N sodium thiosulphate with constant and vigorous shaking until the blue colour just disappeared. A blank test was also carried out in similar manner. The volume of the 0.1 N sodium thiosulphate required was recorded.

$$PV = \frac{(Va - Vb)\ N\ X\ 100}{W}$$

where:
Va = Volume of sodium thiosulphate solution used in the titration
Vb = Volume of sodium thiosulphate solution used in the blank test
W = Weight of the sample in grams
N = Normality of sodium thiosulphate.

Saponification Value of the Oil

Determination of the saponification value of the desert date kernel oil was carried out according to the AOAC (2008) method, where 1 g of the oil sample was transferred into 200 ml conical flask, and the 25 ml of 0.1N alcoholic KOH solution was added. The flask and its content were boiled under reflux for one hour with frequent rotation, then 1 ml of phenolphthalein indicator was added while the solution was still hot, and the excess alkali was titrated with 0.5N HCl, with the volume of HCl required to complete the titration recorded. The same procedure was repeated for the blank and the volume of HCl required to complete the titration also recorded.

$$Saponification\ Value = \frac{(b - a)\ \text{x}\ 0.02805\ \text{x}\ 1000}{S}$$

where;
a = Volume of HCl used to titrate the sample
b = Volume of HCl used to titrate the blank
S = Weight of oil in gram.

Iodine Value of Oil

The iodine value (IV) of the oil sample was determined according to the BSI (1985) method as adopted by Mohamed and Mohammed (2018), where 0.26 g of the sample was weighed into a glass stoppered flask and then dissolved with 10 ml cyclohexane. Then 20 ml of Wijs solution (iodine monochloride dissolved in acetic acid) was added and the flask was stoppered and then allowed to stand in the dark for 30 minutes at a temperature of 25^{O}C after which 20 ml of 10% potassium iodide solution was added. The mixture was then titrated against 0.1 M $Na_2S_2O_3$ using starch as the indicator. The analysis was then carried out using a blank, and the iodine value was calculated using the following formula (AOAC, 2008).

$$Iodine\ Value = \frac{12.69\ x\ C(V1 - V2)}{\text{Weight of } Sample\ in\ gram}$$

where;
C = Concentration of $Na_2S_2O_3$ solution,
V1 = Volume of $Na_2S_2O_3$ used for the blank,
V2 = Volume of $Na_2S_2O_3$ used for the sample

Determination of Fat Content

The Gerber method for the determination of the fat content of the desert date kernel oil was employed in accordance with the procedure reported by Richardson, (1985) and adopted by Gemechu *et al.,* (2015). Here 5 mL of each of the oil sample was mixed with 10 mL of sulphuric acid (specific gravity 1.82) into butyrometer and 1 mL of amyl alcohol was then added. The butyrometer was then closed with rubber cork, and the content was vigorously shaken until all the oil was digested by the acid. The butyrometer was then placed in a water bath at 65^{O}C for 5 minutes. The sample was centrifuged for 5 minutes, and then transferred back to the water bath at 65^{O}C for 5 minutes, and the percentage fat was recorded from the butyrometer.

Free Fatty Acid (FFA) of the Oil Sample

To determine the free fatty acid content of the desert date kernel oil, 2g of the oil was placed in a 250 mL conical flask and warmed, and 2.5 mL of methanol was added with constant stirring, followed by 3 drops of phenolphthalein indicator, and this was then titrated against 0.14 M potassium hydroxide solution with vigorous shaking until a permanent light pink color, which persisted for 1 min, was observed (Afolabi, 2008; Ogala *et al.,* 2018). The end point was recorded, and the free fatty acid value was calculated using equation.

$$\%\ Free\ Fatty\ Acid = \frac{V\ x\ M\ x\ 28.2}{W}$$

where;
V = Volume of potassium hydroxide used
M = Molarity of potassium hydroxide used
W = Weight of the Sample.

RESULTS AND DISCUSSION

Results

The results for the proximate composition and the mineral content of the desert date kernel are presented in Tables 1 and 2 respectively, while the physical and chemical characteristics of the desert date kernel oil are presented in Tables 3 and 4 respectively.

Table1: Proximate Composition of Desert Date Kernel

S/NO	Constituent	Mean concentration (%)
1	Moisture Content	3.19 ± 0.0286
2	Ash Content	2.89 ± 0.0498
3	Fat Content	39.63 ± 0.5012
4	Crude Protein Content	33.75 ± 0.1008
5	Crude Fiber Content	13.06 ± 0.0473
6	Carbohydrate Content	7.48 ± 0.0295

Table 2: Mineral Content of Desert Date Kernel

S/NO	Mineral	Mean Concentration (mg/100g)
1	Potassium	1.120 ± 0.019
2	Calcium	0.390 ± 0.040
3	Sodium	0.801 ± 0.016
4	Magnesium	0.142 ± 0.098
5	Iron	0.0024 ± 0.0016
6	Manganese	0.01512 ± 0.0053
7	Zinc	0.0082 ± 0.00043
8	Copper	0.00225 ± 0.00021
9	Nickel	0.00582 ± 0.00032
10	Cobalt	0.002623 ± 0.00032
11	Chromium	0.003224 ± 0.00051

Table 3: Physical Characteristics of the Oil

S/NO	Parameter		FAO/WHO STANDARD
1	**Color**	**Pale Yellow**	
2	**Density g/cm^3**	**0.910**	**0.909**
3	**Specific Gravity**	**0.907**	**0.9 – 1.16**
4	**Refractive Index**	**1.458**	**1.4677 – 1.4705**
5	**Viscosity**	**19.68**	**19.79**

Table 4: Chemical Characteristics of *B. aegyptiaca* Kernel Oil

S/NO	Parameter	Desert Date Kernel Oil	FAO/WHO Standard
1	Acid Value (mgKOH/g)	3.06	4
2	Free Fatty Acid	1.27	5.78 – 7.28
3	Peroxide Value (mEq/Kg)	3.71	< 10
4	Saponification Value (mg/KOH/g)	198 ± 0.16	195-205
5	Iodine Value 100/g	98.73	80 – 106

DISCUSSION

Moisture content is one of the most important component of food processing, preservation and testing of foods. The amount of dry matter in a food is always inversely proportional to the amount of moisture it contains as such moisture content is of direct economic importance to both the consumer and processor. Of even greater significance, however, is the effect of moisture on the stability and quality of foods, with foods that contains too much water easily subjected to rapid deterioration from mold growth, bacterial attack, insect damage and sprouting (Pomeranz and Meloan 1994). The moisture content of the desert date kernel was found to be 3.19%, and this was found to be below that reported by Jock (2011) and Ogala *et al.,* (2018) who respectively reported moisture contents of 7.23% and 7.16%. However, the findings of this study agree with reports by Sara and Mahdi (2016) who reported a moisture content of 3.74%; Elbadawi *et al.,* (2017) who reported 3.13%, and Alhassan *et al.,* (2018) who reported 4.08%. The differences could be attributed to the variety of the plant available and the soil it was grown on (Gabriel *et al.,* 2018).

Ash content refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in the food sample. The ash content is the measure of the total amount of minerals present within a food, with its determination along that of the mineral contents of the foods important in nutritional labeling of the food, microbiological stability and processing. It is also an important quality attribute for some food ingredients, as well as the first step in the preparation of a sample for specific elemental analysis (Baraem 2017). The ash content of the sample analyzed was found to be 2.89%. This result was found to be in agreement with reports by Jock (2011); Sara and Mahdi (2016); Elbadawi *et al.,* (2017); Alhassan *et al.,* (2018) and Ogala *et al.,* (2018).

Fats are one of the three main macronutrients, along with carbohydrates and proteins. Fat is an important foodstuff for many forms of life, and serves both structural and metabolic functions. They are a necessary part of the diet of both humans and animals, and the most efficient form of energy storage (Pickova 2009). The crude fat or oil content of the kernel of the desert date was found to be 39.63% and this result is supported by similar reports by Jock (2011); Lohlum (2012); Sara and Mahdi (2016); Elbadawi *et al.,* (2017); Alhassan *et al.,* (2018) and Ogala *et al.,* (2018). The result is however lower than that reported by Elfeel (2010) who reported 50% fat content. Oil provides concentrated energy in the diet and enhanced palatability (Hassan *et al.,* 2008). The high fat content of the kernel of the desert date is an indication that it can be a good source of fat.

Proteins are some highly complex substances present in all living organisms. They are said to be of great nutritional value, and directly involved in nearly all the chemical processes essential for life. They are also involved in growth and maintenance of the body; they cause biochemical reactions; they act as messengers; they provide structure to the body; they help in maintaining proper pH; they maintain the balance of the body fluids; they bolsters the immune health; they transport and store nutrients; they also provide energy to the body (Shahidi and Senadheera 2019). In this study, the percentage protein

content of the kernel of the desert date was found to be 33.75% and this agrees with similar reports by Jock (2011); Lohlum (2012); Sara and Mahdi (2016); Elbadawi *et al.,* (2017); Alhassan *et al.,* (2018) and Ogala *et al.,* (2018). Protein being an essential component of the diet required for the survival of both humans and animals (Pugalenthi *et al.,* 2004), then kernel of the desert date can serve as a source of this important nutrient.

Crude fiber is usually a measure of the quantity of indigestible lignin, cellulose and other components. It consists largely of 60-80% cellulose and 4-6% lignin, in addition to other mineral matter. There is an increasing need to include food rich in fibre diet, as they help to prevent colon cancer (Rock 2007; Haritha and Ayona 2017). Fibers also are essential in treating or preventing diverticulosis, hemorrhoids, coronary heart diseases and constipation (Chandaka *et al.,* 2017). The kernel seed analyzed in this study was found to contain an appreciable amount of crude fibre (13.06%), and this was found to agree with that reported by Jock (2011); Lohlum (2012); Sara and Mahdi (2016); Elbadawi *et al.,* (2017); Alhassan *et al.,* (2018) and Ogala *et al.,* (2018). Crude fiber is known to expand the inside walls of the colon, easing the passage of waste, and this makes it quite effective against constipation (Betty *et al.,* 2016).

Carbohydrates, alongside fats and proteins, are one of the three macronutrients in our diet with their main function being to provide energy to the body. Carbohydrates come in many different forms, ranging from sugars to dietary fibres, and in many different foods, such as whole grains, as well as fruit and vegetables (Cummings and Stephen 2007). The carbohydrate content of the desert date kernel analyzed in this study was found to be 7.48% and this agrees with that reported by Sara and Mahdi (2016); Elbadawi *et al.,* (2017); Alhassan *et al.,* (2018) and Ogala *et al.,* (2018).The low carbohydrate content the kernel of the desert date means that the kernel is not an excellent source of carbohydrate.

The mineral content of the desert date kernel was found to be as follows; potassium (1.120 mg/100g); calcium (0.390 mg/100g); sodium (0.801 mg/100g); magnesium (0.142 mg/100g); iron (0.0024 mg/100g); manganese (0.01512 mg/100g); zinc (0.0082 mg/100g); copper (0.00225 mg/100g); nickel (0.00582 mg/100g); cobalt (0.002623 mg/100g); chromium (0.003224 mg/100g). The results show that the kernel is rich in potassium, calcium, sodium and magnesium, while other minerals are also present in appreciable amounts. The findings in this study agree with similar findings reported by Jock (2011); Lohlum (2012); Sara and Mahdi (2016); Elbadawi *et al.,* (2017); Alhassan *et al.,* (2018) and Ogala *et al.,* (2018). Potassium and sodium are electrolytes needed for the body to function normally and help in maintaining the fluid and blood volume of the body. However, when there is an in-balance between the two, a person may develop high blood pressure, that is by consuming too much sodium and not enough potassium (USDHHS 2015). Potassium and sodium also help in regulating the water balance and the acid-base balance in the blood and tissues (Kowey 2002). Calcium is essential to maintaining total body health. Our bodies need calcium every day not just to keep our bones and teeth strong over but to ensure proper functioning of muscles and nerves, and also help our blood to clot. Calcium deficiency is usually due to an inadequate intake of the mineral when the blood calcium levels drop too low, as such how much calcium we get is very important to our health (Piste *et al.,* 2013). Magnesium, the fourth most common mineral in the human body after calcium, sodium and potassium, is also the second most common intracellular cation after potassium. Magnesium is a cofactor in many enzyme systems and is also required for such fundamental processes as energy production and nucleic acid synthesis, and plays an important role in the synthesis of ATP (adenosine triphosphate) from ADP (adenosine diphosphate) and inorganic phosphate (Gerry and Stephen 2017). Copper helps the body form collagen and absorbs iron, and plays a role in energy production. Zinc plays a role in wound healing as well as treatment to diarrhea. Iron is a mineral that serves several important functions, its main function being to carry oxygen throughout our bodies and making red blood cells (Beard and Dawson 1997). Manganese, along with vitamin K, plays a role in blood clotting and hemostasis (Aschner and Aschner 2005). It is also an essential trace element naturally present in many foods or available as a dietary supplement, and serves as a cofactor for many enzymes (Nielsen 2012; Buchman 2014). Due to the reasonable concentrations of some of these minerals in the desert date kernel, it can easily be said the kernel can serve as an excellent supplement for these minerals for human body.

The quality analysis of *Balanites aegyptica* kernel oil was done by analyzing some physical such as the oil color, its density, specific gravity, refractive index and viscosity. The observed colour of the oil was pale yellow, and this has been the findings of Ogala *et al.,* (2018). The density of the kernel oil studied was found to be 0.910 which agrees with that reported by Babeker (2013) and just above that reported by Ogala *et al.,* (2018) who reported 0.87, and just below than that reported by Manji *et al.,* (2013) who reported a value of 1.001. However, the finding of this study is within the FAO/WHO standards of 0.909. The specific gravity of the desert date kernel oil in this study was found to be 0.907, and this result is in agreement with that reported by Jock (2011) Manji *et al.,* (2013) Haftu, (2015) Sara and Mahdi (2016) Elbadawi *et al.,* (2017), and within the 0.9–1.16 range set by the FAO/WHO standards. The refractive index of 1.458 is just a little below the FAO/WHO standard of 1.4677-1.4705, but still near similar to that reported by Babeker (2013) and Manji *et al.,* (2013). The viscosity of 19.68 recorded in this however found to be in agreement with similar reports by Babeker (2013).

The acid value of 3.06 mgKOH/g and observed in this study is just below the FAO/WHO standard of 4 mgKOH/g, but still shows that the oil is stable (Haftu, 2015). While the free fatty acid content of 1.27% is far below the FAO/WHO standard limits of 5.78-7.28%. Oils with high acid value (above 4 mgKOH/g), also implying a high percentage free fatty acid content, will develop unpleasant smell and rancid odour due to the hydrolysis of the free fatty acids due to storage. The acid value and the percentage free fatty acid of *Balanites aegyptica* seed kernel oil are all lower than FAO/WHO standard for edible oils. The lower the percentage free fatty acid content the less the tendency of the oil to undergo hydrolytic activities. However, the results for the acid value and the free fatty acids obtained in this study are in agreement with similar findings by Manji *et al.,* 2013 and Jock 2017, but lower than that reported by Ogala *et al.,* 2018.

The peroxide value, used as a measure of the extent to which rancidity reactions have occurred during storage, is used as an indication of the quality and stability of fats and oils. The peroxide value determined for the kernel oil of *Balanites*

aegyptica was found to 3.71 mEq/g and is within the FAO/WHO standard of less than 10 mEq/g, and the lower the peroxide value the more suitable is the oil for a long storage, implying longer shelf-life (Adegbe *et al.,* 2016). The results of this study agree with similar reports by Mohammed *et al.,* (2017) and Mohamed and Mohammed (2018), but far lower than reported by Babeker (2013) and Manji *et al.,* (2013) who respectively reported 8.0 and 6.0 mEq/g).

The saponification value, which is an index of average molecular mass of fatty acid in the oil sample, was found to be 198 mgKOH/g for *Balanites aegyptica* kernel oil analyzed, and this value is within the FAO/WHO range of 195–205 mg KOH/g for edible oils. The result agrees with similar reports by Babeker (2013), Manji *et al.,* (2013), Mohammed *et al.,* (2017) and Mohamed and Mohammed (2018). The saponification value of oil is an important quality in determining the suitability of the oil for soap making.

The iodine value measures the degree of unsaturation in fats or oils. It determines the stability of oils to oxidation and allows the overall unsaturation of the fat to be determined qualitatively. The iodine value of the desert date kernel oil analyzed in this study was found to be 98.73 100/g and within the range of the FAO/WHO standard of 80-106 100/g. The result was in agreement to similar reports by Babeker (2013), Manji *et al.,* (2013), Mohammed *et al.,* (2017) and Mohamed and Mohammed (2018). Oils with iodine values below 100 are non-drying, while those having values between 100 -130 are semi-drying and those with values above 130 are termed drying oils (Jock 2018).

CONCLUSION

Desert date has been in used traditionally for the treatment of many diseases and ailments. This study revealed that the seed kernel of this plant is of high nutritional value, and also contains many mineral elements in significant amounts. The oil of the seed of this plant can be a good source of raw material for many oil-based products like lubricants, shampoos, soap and bio-diesel, more so, the oil could also be utilized as a an excellent source of edible oil for human consumption as it can make a good dietary source and/or supplement for some minerals.

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