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Physicochemical properties of *Balanites aegyptiaca's* seeds and seed oil from Southern Algeria

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Abstract

The current study aimed to evaluate the physicochemical properties and chemical compositions of *Balanites aegyptiaca* seeds and seed oils collected in southern Algeria; the seed oil was extracted using a screw press to separate the crude oil. The elemental composition of the seed revealed a high metal concentration of magnesium (1.7±0.2 mg/g) in the seed kernel, and a low concentration of chrome and lead. The total protein content of the seed averages (0.96±0.03%). *Balanites aegyptiaca* provided a yield of 26.3±0.16 crude oil. The physical parameters determined were density, and refractive index. These were found to be 0.90±0.03, and 1.472±0.00 respectively. The chemical parameters evaluated include the moisture content 0.114±0.04% , saponification value (226.67±0.11 mg KOH/g) , acid value (0.93±0.05) (mg KOH/g) , iodine value (125. 33±0.07 100/g) , peroxide value 3.96±0.05 (mEq/kg) and free fatty acid; the Carotenoid composition 2.33 ±0,1 (Mg/kg). In general, the seed and the press-extracted oil had good physicochemical properties and could be used in industrial applications and biological research.

Key words*: Balanites aegyptiaca* , seeds, chemical compositions, seed oil, physicochemical properties , southern Algeria.

1. Introduction:

Fats and oils are among the most complex and contentious fields of research in human nutrition [1]. The properties, fatty acid and triglyceride contentsof oil were used to determine its competency for a specific application and purpose. Physical and chemical properties can be used to assess the quality of vegetable oils. Oil seeds have actually received oils, animals' feeds, pharmaceutical industries, bioenergy, and other oleo-chemical industrial applications has improved [2]. *Balanites aegyptiaca* (lalob-Helgleg) is a tree belongs to *Zygophylacea* family (*Balanitaceae*). It is a wild tree found in dry and savannah areas of Africa and South Asia [3]; it can grow in a wide range of environments, soil, and climatic conditions.

Furthermore, the tree has excellent adaptative mechanisms that allow it to grow and thrive under combined salinity stresses [4].

The fruits are edible and known as desert dates [5], in southern Algeria *Balanites aegyptiaca* is locally called Tabourak, Techeit and Touga,

The tree is highly valued in the Sahelian and Saharan regions for its wood, edible fruits (sweet mesocarp and kernel oil), animal feed value, and various ethnomedicinal uses [6].

The seed is rich in oil, protein, and mineral contents[3]. In quality aspect, it is similar to sesame and groundnuts oils .The oil of *Balanites aegyptiaca* is good and edible quality with highest percentage of fatty acids. The oil exhibited anticancer activity against lung, liver, and brain human carcinoma cell lines. It also had antimutagenic, antiviral and

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antimicrobial activities against selected microorganisms [7]. Moreover it is used to treat skin diseases, diabetes and hypoglycemia [4] Seed also used for biodiesel production [8].

The oil that is considered in this research is organic oil, a triglyceride extracted from a plant source (seed kernel of *Balanites aegyptica*) and is generally referred to as vegetable oil which are also widely used in bioresources [9].

Also, investigated the toxicological aspects of seed oil, concluding that crude oil did not cause market changes in the toxicological parameters of experimental animals, implying that crude oil is edible and that consumption of crude oil at current levels of exposure may pose no serious safety risk, particularly in terms of liver and kidney injury [7].

Few articles have been published on the characteristics and potential applications of *Balanitesaegyptiaca* oil [10]. Despite these products, Balanites are recognized as one of the underexploited and ignored arid zone tree species that require domestication [11].

So, because demand for vegetable oil is increasing around the world, it's also important to find good sources for producing high-quality oil that can be used in industry.

More research is needed into the cold pressing process technique, which could result in higher oil yield and better physicochemical properties of oil extracted from the *Balanites aegyptica* kernel [12].

This study is therefore aimed to investigate the physicochemical properties of Balanites aegyptiaca's seeds and seed oil from south of Algeria.

2. Materials and methods:

2.1. Chemical reagents:

All chemical reagents were supplied by Sigma Aldrich.

2.2. Equipment:

Press oil machine DL-ZYJ05. An atomic absorption spectrophotometer apparatus with an atomic absorption graphite furnace and a domaine flame SAA Shimadzu AA7000. Distillation and titration unit Kjeldahl with autosampler and FOSS digestion unit with programmer (Kjeltec 2400 FOSS). 6715 UV/Vis Spectrophotometer JENWAY.

2.3. Plants materials

The fruits of *Balanites aegyptiaca* were collected from three regions in southern Algeria: Adrar (A) ,Beni-Abbes (B) , and Tamnrasset (T) ; mechanical peeling of dried fruits to remove dry pulp; and almond recovery after crushing the stones with a screwdriver.

2.4. Proximate characterization of the seed kernel

2.4.1. Ash and mineral content:

To determine the ash content, 5.0g of seed flour was incinerated For 05 hours in a muffle furnace at 550°C.The average amount of ash was determined by weight difference [13]. For the mineral content, the residues of the ash content were dissolved in 50mL of 0.5M HNO_3 solution. Mg, Cr, and Pb concentrations were determined using atomic spectrophotometer absorption; a calibration curve was created using standard metal solutions [14].

2.4.2. Protein content:

The protein content was determined by the Kjeldahl method with a copper sulphate-sodium sulphate catalyst [15].

2.5. Oil extraction:

A mechanical press for extracting seed oil was recently introduced. The oil seed raw materials will be ground using a screw press oil machine to separate the crude oil, which will then be centrifuged and filtered to remove solid particles and traces of water; the remaining residues, known as cake, will contain fiber, protein, starch, but also oil [16].Supernatant solution was collected which was the mixture of the extracted oil.

Figure 01: a- *Balanites aegyptiaca* leaves; b- *Balanites aegyptiaca* fruits with measocarp ; e- *Balanites aegyptiaca* dried fruits d- *Balanites aegyptiaca* seed; e- *Balanites aegyptiaca* seed oil

2.6.Physical and Chemical Characterization of Balanites aegyptiaca seed oil

Methods conform to AFNOR [17] and ISO methods have determined the acid index, ester index, specific density at 20°C; Refractive index (RI) was measured with a refractometer at 20°C.

2.6.1.Moisture content: Five grams of oil sample were weighted in an aluminum capsule and placed in an oven at 105 °C for approximately 5 h until a constant weight was obtained [18].

2.6.2.Density: The density of oil is the ratio of the mass of a given volume of oil at 20C°. The relative density was determined through a series of weighing with a pycnometer according to (NF ISO, 6883) method [19].

2.6.3.Refractive index: The determination of Balanites seed oil refractive index was performed using a refractometer at 20 °C. The refractive index parameter would help in detecting the adulteration of seed oil with edible vegetables oils [20].

2.6.4. Iodine value: This parameter was carried out as described by ISO 3961 [21]. (2.0 g) of crude oil was measured into a 100 ml conical flask and Dams iodine (5 ml) was added to it, the flask was corked and placed in a dark cupboard for 5 min. 10% KI (5 ml) was added followed by distilled water (20 ml). The solution was titrated with 6.6% sodium thiosulphate in the presence of 1% starch indicator (1 ml) until the blue color turned colorless.

2.6.5. Peroxide value: The oil's peroxide value was calculated using the standard method (NF in ISO 3960) 5.0 g of Balanites oil was added to a 25 ml acetic acid chloroform (3:2) solution, along with 1 ml of saturated KI solution, and the solution was stirred until the oil was completely dissolved. 75 ml of distilled water was added after incubating the solution in the dark for 1 hour at room temperature. Finally, the solution was titrated with 0.01 N Na2SO3 until the color changed to colorless, using a starch solution as an indicator. The volume of the titration was measured [22].

2.6.6. Acidity: The free acidity content was expressed as a percentage of oleic acid. The free acidity of the oil samples was determined using ISO 660 method [23], which involves measuring the fatty acids released during triglyceride hydrolysis with a sodium hydroxide solution.

2.6.7. Saponification value: Saponification ratio described by ISO 3657 [24]. 02 g of the oil sample was weighed into a 250 mL quick fit flask and 25 mL of 0.5 methanolic KOH was added. The flask was connected to an air condenser and boiled for 1 hour, or until all of the fat was saponified. While the solution was still hot, it was titrated with 0.5M HCl to a colorless end using phenolphthalein as an indicator. Concurrently, a blank titration was performed.

2.6.8. Chlorophylls and carotenoids: The analysis of oil pigments were carried out following the spectrophotometric method described by Mínguez-Mosquera et al. [25].The absorbance at 670 nm and 470 nm was detected to determine the chlorophylls and carotenoids content, respectively. Chlorophyll and carotenoid total fractions were expressed as mg/kg of oil using the respective coefficient of extinction (613 and 2000).

2.6.9. Extinction coefficients for K232 and K270: k232 and k270 extinction coefficients were evaluated from absorbance at 232 and 270 nm, respectively, using a UV spectrophotometer with a 1% solution of oil in cyclohexane and a path length of 1 cm [26].

3. Data analysis:

All physicochemical measurements were performed at least in triplicate in this study, and all data were analyzed. All results are
shown as the average of the measurements. A one-way ANOVA was used to test for significant differences between means at p values of < 0.05. The averages of the parameters of samples A, B, and T are significantly different at 0.05 using one way
ANOVA Test.

4. Results and discussions:

4.1. Proximate composition of the seed kernel:

The moisture of the seed kernel A, B, T was 0.16 ±0.01% ; 0.10±0.02%; 0.10±0.02% respectively. These result is compared with previous study;7.23±0.06% reported by [27] and 0.27% reported by [28].

The ash content of the seed kernel was 3.40±0.12% ; 4.00±0.11% ; 4.60±0.09% respectively and is similar with previous studies (3.19±0.06%) [29] and 3.98% [30]. This is the measure of the total amount of minerals present in a food. The mineral content of a food is a measure of the amount of specific inorganic components present and ash is the inorganic residue remaining after the water and organic matter have been removed [6].

Protein content of the seed kernel was 0.77±0.03 ; 1.05±0.04 ; 1.07±0.04 % respectively. Our results are comparable to that of [31] who found a concentration of Protein about 112.43 mg/l. The total crude protein of Balanites kernels ranged between 26.3 % and 42.8 % in the 13 fruit accessions collected from different parts of Sudan [32]

Table 01: Proximate composition of the seed kernel

	Seed A	Seed B	Seed T	Significance
Moisture %	0.16 ±0.01	0.10±0.02	0.10±0.02	Ns
Ash %	3.40±0.12	4.00±0.11	4.60±0.09	***
Proteins%	0.77±0.03	1,05±0.04	1.07±0.04	***
Mineral				
Mg mg/g	1.7×10^{-3}±0.00	1.74×10^{-3}±0.00	1.42×10^{-3}±0.00	***
Cr mg/g	0.0136±0.00	0.014±0.00	0.0016±0.00	***
Pb mg/g	0.065×10^{-6}±0.00	50×10^{-6} ±0.00	70×10^{-6} ±0.00	***

*≤ 0.05; **≤ 0.01; ***≤ 0.001; ns =no significant difference

The averages parameters of samples A, B, and T are significantly different at 0.05 using one way ANOVA Test

The results of the concentration of trace metals in seed kernel *Balanites aegyptiaca* are shown in **table 01**. The presence of trace metals is an important factor as far as the quality of kernel seed and oils; metallic elements such as Mg , are essential human nutrients mainly for growth.

Pb pose detrimental effects on health of plants and animals even in relatively small amounts [33].
These metals are required by the body for certain physiological activities; lead has the lowest concentration in the seeds (65×10-6 0.00mg/g). One of the most toxic heavy metals is lead. Lead's toxicity to humans is well known, it replaces calcium and consequently, can accumulate in the skeletal system. Human lead exposure has been linked to a variety of neurodevelopmental effects, cardiovascular disease, impaired renal function and fertility, hypertension, and poor pregnancy outcomes [34]. However, lead concentration in the seed kernel and seed kernel oil was within admissible limit of 0.01 mg/g by World Health Organization [35].

4.2. Physicochemical characteristics of the seed oil:

Physico-chemical characterization of oils covered the determination of quality and the alteration criteria. The values obtained were compared to those given by the FAO/WHO standard [36]. The results depicted in **Table 02** present the physical profile of oils tested. The exploitation of these results shows variability in the extraction yield (23.33; 29.41 and 25.98%), respectively for *Balanites aegyptiaca* A, B, T oils.
The moisture contents of the oil A, B, T was 0.15 ±0.02%; 0.10 ±0.01%; 0.25±0.01% respectively; High moisture content causes oil seeds to deteriorate. This occurs when heat is generated by an oxidation reaction, which raises the temperature of the storage seed and accelerates deterioration to the point of carbonization the seed. Moisture content indicates a food's storability and nutritional values; thus, low respectively. Iodine value of Balanites oil is relatively superior to that of 100.52 gI2/100 g [38] and (80.62 ; 79.64) [12]

Table 02: Physical characteristics of *Balanites aegyptiaca* seed oil

	Oil yield %	**Moisture %**	**Density**	**Refractive index**
Oil A	23.33±0.15	0.15 ±0.02	0.901±0,03	1.472±0.00
Oil B	29.41±0.11	0.10 ±0.01	0.900±0.08	1.473±0.00
Oil T	25.98±0.23	0.25±0.01	0. 910±0.03	1.472±0.00
FAO standard		0.2 %	20˚C 0.911-0.929	at 20˚C 1.468-1.475
Significance	***	***	ns	ns

The averages parameters of samples A, B, and T are significantly different at 0.05 using one way ANOVA Test ANOVA Test. *≤ 0.05; **≤ 0.01; ***≤ 0.001; ns =no significant difference

The peroxide value is used to determine the extent to which lipid oxidation reactions occur during storage and could be used to measure the quality and stability of fats and oils.

The peroxide value determined for the seed kernel oil of *Balanites aegyptiaca* A, B, T was 3.73±0.06; 4.13±0.08; 4.01±0.02mEq/g respectively and is lower than FAO/WHO standard shown in Table 02. These results are lower to that of 2.95 ± 0.00 mEq/g [9]. A low peroxide value in the current study increases the oil's suitability for long-term storage due to low levels of oxidative and lipolytic activities [39].

Saponification value is an index of average molecular mass of fatty acid in the oil sample. The saponification value of the oil A,B,T was 221.35±0.09 ; 226.67±0.13 ; 232±0.11 mg KOH/g respectively which is comparable to the values of certain vegetable oils like; sesame, neem, groundnut, palm kernel, castor oils, etc and these value are Higher than 168.,6 mg KOH/g [40]; 186.28 mg KOH/g [38] . The saponification value obtained of *Balanites aegyptiaca* seed kernel oil was 200.02mgKOH/g. The value is within the range of 195–205 mg KOH/g for edible palm oils [41].

Table 03: assessment of Balanites *aegyptiaca seed* kernel oil

	Iodine value g/100g	**Peroxide value meq. O2/kg**	**Saponification Value**	**Acide value KOH mg/g oil**	**Acidity%**	**Chlorophyll Mg/kg**	**Carotenoid Mg/kg**	**Extinction k232**	**Extinction K 270**
OIL A	125.71±0.09	3.73±0.06	221.35±0.09	0.89±0.02	0.46±0.01	0.23±0.04	2.34±0.13	0,05±0,01	0,04±0,01
OIL B	119.92±0.03	4.13±0.08	226.67±0.13	0.97±0.03	0.50±0.01	0.27±0.01	2.31±0.	0,04±0,01	0,04±0,01
OIL T	130.38±0.08	4.01±0.02	232±0.11	0.99±0.11	0.55±0.02	0.18±0.01	2.33±0.11	0,03±0,02	0,04±0,02
FAO Standard	85-109	15	230-254	4.0			500-2000		
Significance	***	*	***	ns	***	ns		ns	ns

The averages parameters of samples A, B, and T are significantly different at 0.05 using one way ANOVA Test ANOVA Test. *≤ 0.05; **≤ 0.01; ***≤ 0.001; ns =no significant difference

The saponification value of oil is an important parameter to determine the oil's suitability for soap production [9].

Acidity is a chemical property of oil that is used to determine its quality and grade [2]. The acid value of *Balanites aegyptiaca* seed kernel oil (A,B,T) was 0.89±0.02; 0.97±0.03; 0.99±0.11 mg respectively, while the free fatty acids value was 0.46±0.01; 0.50±0.01; 0.55±0.02 % respectively which are higher than 0.34± 0.00 % [10].

Acid value was determined to quantify the fatty acid found in the oil as it measures the free fatty acids of oil. The acid value was low (2.14±0.28 mg KOH/g) and this shows that the oil is stable [42] . Oils with high acid value, also implied high % FFA and will undergo rancidity due to the hydrolysis of the free fatty acids on storage. The acid value and % FFA of *Balanites aegyptiaca* seed kernel oil are lower than FAO/WHO standard for edible oils (Table 02).

The low percentage of FFA reduces the tendency of the oil to lipolysis activities. In most oils, the level of free fatty acid which causes deterioration is noticed when the % FFA calculated as oleic acid falls within the range of 0.5 - 1.5%[39].With a free acidity of less than 1%, oils stored for four months can be classified as extra virgin oil for the first time [43].

Chlorophylls and carotenoids play important rolesin auto- and photo-oxidation processes [44]. They are responsible for the color of the oil, which is a very important attribute to evaluate its quality. According to Table 03, the carotenoid and chlorophyll contents for Balanites aegyptiaca oil A, B, T were 0.23±0.04; 0.27±0.01 ; 0.18±0.01mg/kg and 0.23±0.04 ; 0.27±0.01 ; 0.18±0.01mg/kg respectively [1].

The extinction coefficients for K232 and K270 K232 A, B, T was 0.05±0.01; 0.04±0.01; 0.03±0.02The K values measured at 232 nm and 270 nm are related to changes in the content of conjugated dienes and trienes formed during the oxidation of polyunsaturated fatty acids. It is a measure of oil quality and oxidation/rancidity respectively K270 0.04±0.01; 0.04±0.01; 0.04±0.02 respectively, K232 levels generally rise as a result of improper fruit storage or outdated extraction or standardization procedures. K270, on the other hand, rises when the oil is old and as a result of previous harvesting [1].

6. Conclusion:

The present study was based on the physicochemical properties and chemical characterization of oil extracted from *Balanites aegyptiaca* seeds. We observed that the seed of this plant contains a significant amount of oil. The analysis of variance revealed a highly significant difference in seed kernel mineral contents and chemical characteristics between oils from different regions of Algeria's south. Our studies demonstrated the high quality of the press-extracted oils; this technology preserves the chemical composition of the oil and can be used successfully as a source of dietary oil for human consumption. The oil could also be a great source of biomolecules and raw materials for many oil-based products. (Cleansers, biodiesel, fuel additives, and other product).

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