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Studies on the potentials of *Balanites aegyptiaca* seed oil as raw material for the production of liquid cleansing agents

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The seed oil of *Balanites aegyptiaca* was extracted and its chemical and physical properties were evaluated. The chemical parameters investigated include: saponification value (SV), iodine value (IV), peroxide value (PV) and free fatty acid (%FFA). These were found to be 168.6 mgKOH/g, 78.7 gI_2/100 g, 6.0 mEq/kg and 0.18 mgKOH/g, respectively. The physical parameters evaluated include: percentage yield (49.9%), specific gravity (0.927), refractive index (1.4784) and moisture content (0.27%). Saponin was also screened for and was found to be present. Thus the results have shown that the oil is non-drying and contain saponin; this then suggests that the oil is a good raw material for the formulation of liquid cleansing agents. Liquid soap and shampoo were then formulated using the oil and the properties of the products were evaluated. From the results, it was found that the products compared favourably to similar products sold in the market in terms of pH, colour, percentage alkali and solubility in water.

Key words: Seed oil, liquid soap, saponin, Nigeria.

INTRODUCTION

Balanites aegyptiaca is a tree, which belongs to the Balanitaceae family of plants. Its English name is Desert date, Høba call it Baha, Hausa call it Adu'a and the Fulanis call it Tanni. The tree is wide spread in the drier regions of Africa from Mauritania to Nigeria, Eastward to Ethiopia, Somalia and East Africa. It is also found in Israel, Arabia, India and Pakistan (Sulaiman and Jackson, 1959). There are about 25 known species of the plant widely distributed from tropical Africa to Burma (Usher, 1984). It is a savannah tree, which attains a height of more than 6 m; it has a spherical crown and tangled mass of long thorny branches (Sulaiman and Jackson, 1959). The leaves are subsessile or shortly petiolate, grey green in colour, orbicular, rhomboid or obviate in shape, often measuring 3.6 - 6 by 2 - 5 cm, the apex is acute or rarely obtuse. Spines are simple or very rarely bifurcate, up to 5 cm long and alternate in the axils (Brown, 1979). The flowers are yellow-green in colour and up to 4 cm long and 2.5 cm in diameter. The fruit has thin brittle epicarp, a fleshy mesocarp and a woody endocarp containing the oil seed or kernel.

The term oil is used in generic sense to describe all substances that are greasy or oily fluids at room temperature. They are non-volatile and are insoluble in water but are soluble in organic solvents. Oils from seeds or kernels or nuts along with proteins and carbohydrates, constitute the majority of foodstuffs. They are also found in wide industrial applications, like formulation of soap,

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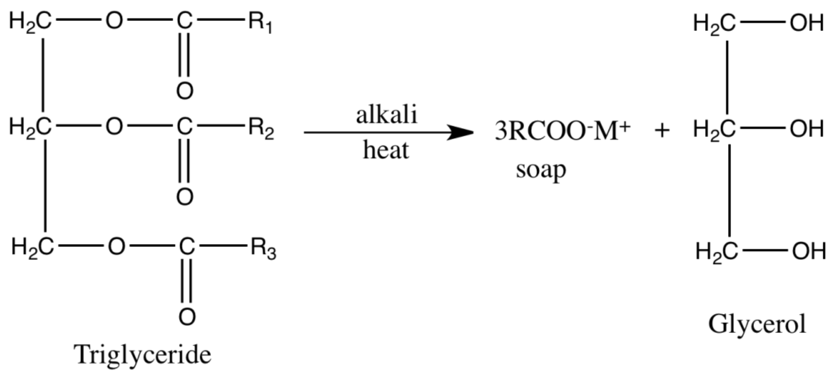

Scheme 1. Saponification process. Triglyceride (oleic or stearic or palmitic or lauric acid), alkali (NaOH-hard soap or KOH-soft/liquid soap), M (Na or K).

toiletries, paints, varnishes, bio-diesels and lubricant.

The criteria for the selection of oil for industrial use are: presence of natural characteristic aroma, clarity, good natural colour, very low moisture content, freedom from solid particles and freedom from flat and rancid (unpleasant) odour (Okoye, 1999). Studies have shown that *Balanites roxburghi,* a native of India and Pakistan, locally referred to as 'Higin ingudi' yielded an edible seed oil (Zachun oil), and the fruits were found to contain saponin; thus it is locally used to wash silk (Usher, 1984). *B. aegyptiaca* specie, which belongs to the same family with *B. roxburghi* is available in the northeastern part of Nigeria and so the investigation of its oil as source of raw material for soap making is worth trying.

Soap is a surfactant used in conjunction with water for washing and cleaning. It usually comes in solid moulded form, termed bars due to its historic and most typical shape. The use of thick liquid soap has also become widespread, especially from dispensers in public washrooms. When applied to a soiled surface, soapy water effectively holds particles in suspension so the whole of it can be rinsed off with clean water. Many soaps are mixtures of sodium (soda-solid soap) or potasium (potash-liquid soap) salts of fatty acids which can be derived from oils or fats by reacting them with an alkali (such as sodium or potasium hydroxides) at 80 - 100°C in a process known as saponification. The fats are hydrolyzed by the base, yielding glycerol and crude soap (Scheme 1).

Historically, the alkali used was potasium made from the deliberate burning of vegetation such as bracken, or from wood ashes. The use of the word "soap" has become such a household name that even cleaning solutions for the body that do not have soap in the ingredients are referred to as soap (Wikipedia, 2007). The need for soap as a cleansing agent has been felt ever since man became aware of the necessity for cleanliness (Donkor, 1986). Soap therefore acquired the status of a basic necessity of modern civilised world. Soap when used with water, decreases surface tension loosening unwanted particles, emulsify grease and absorb dirt and grime into foam. Its use has increased over the years until its manufacture has become an industry essential to the comfort and health of civilised societies. It is consumed in large quantities on daily basis for laundry, hair dressing, personal and hygiene, in homes and commercial cleansing operations. Textile mills also consume considerable quantity of soap in boiling cotton, scouring wool and silk agitation to remove impurities prior to finished operation and to assist the level of application of softening agents used to improve fabric feed. Thus, because of increased demand for cleansing agents, there is need to evaluate and develop raw materials that have good properties for making varieties of such agents.

Studies have shown that some plants have been used as substitutes for soap. These are plants that contain saponin in sufficient quantities to produce leather (when mashed plant parts are beaten in water) and can be used in either soap or shampoos. The soap plant group (amole root, soap plant root, soap root bulb), guaiac leaves, papaya leaves, Quillaia bark, Red campion root and leaves, Atripex root, Sapindus fruit, soap pod fruit, Mojave yucca root, soapwort root, Our Lord's Candle root, wild gourd fruits are good examples (Wikipedia, 2007). The annual yield of the fruits of *B. aegyptiaca* is very high, thus the availability of the oil is assured. But little is known about the physico-chemical properties of the oil, thus its industrial potentialities are not harnessed.

The present work is therefore aimed at investigating the properties of the seed oil of this plant and to screen for the presence of saponin in the oil since saponin was found in the mesocarp of *B. roxburghi*.

MATERIALS AND METHODS

The fruits were purchased at Girei market in Girei local government area of Adamawa Sate in Nigeria. The chemicals used for the

Table 1. Chemical properties of *Balanites a*. seed oil.

Sapon. value (mgKOH/g)	Iodine value (gI_2/100 g)	%Free fatty acid (mgKOH/kg)	Peroxide value (mgEq/kg)	Saponin
168.6	78.7	0.18	6.0	Present.

Table 2. Physical properties of *Balanites* a. seed oil.

Oil yield (%)	Moisture content (%)	Specific gravity	Refractive index	Class of oil
49.9	0.27	0.927	1.4784	Non-drying

analyses are of Analar grade. The oil was extracted using traditional method as described by Abu-Al-Futuh (1989): seed – crushing to obtain kernel – drying – toasting – grinding – addition of water – extraction of oil – drying the oil. The oil obtained was kept for subsequent investigation. The traditional method is adopted because it gives good oil yield and it checks possible contamination by solvents through solvent extraction. This method is also cost effective, hence even the less privileged can have access to the oil for their small-scale soap production and other uses.

Chemical parameters

Saponification value

This was carried out according to American Oil Chemists Society (AOCS) method (1987). The crude oil (2.0 g) was weighed into a 250 ml conical flask and 10% alcoholic KOH (25 ml) was added. A reflux condenser was attached to the flask and refluxed over steam for 1 h with occasional swirling. Phenolphthalein indicator (1 ml) was added at the end of the refluxing time and the solution was titrated with 0.5M HCl. The result is recorded in Table 1.

Iodine value (IV)

This was carried out as described by Nielsen (1994). The crude oil (2.0 g) 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 colour turned colourless. The value is recorded in Table 1.

Free fatty acid (FFA)

This is the percentage by weight of specified fatty acid (for example, % oleic acid). The method used is as described by Harold et al. (1990). A well-mixed portion of the crude oil (2.0 g) was weighed into a conical flask, a neutralised 1:1 mixture of 95% ethanol and diethyl ether (10 ml) was added and mixed thoroughly. The solution was titrated using 0.1M NaOH and phenolphthalein indicator, shaking constantly until a pink colour, which persisted for 15 s, was observed. The value is recorded in Table 1.

Peroxide value (PV)

This parameter was determined using the method described by Pomeranz and Meloan (1987). The crude oil (1 g) was weighed into a clean dry 100 ml conical flask; to this powdered KI (1 g) was added followed by a mixture of 2:1 glacial acetic acid and chloroform (20 ml). The flask was placed on a steam bath for 30 s and the content was quickly poured into another flask containing 5% KI solution (20 ml). The solution was then titrated using 0.02M sodium thiosulphate solution and starch indicator. The value is recorded in Table 1.

Iodine number-saponification factor (INS)

This factor is expressed as the difference between the iodine number and saponification value of an oil or fat. It is used to predict the quality of soap obtain from oils or fats. The factor ranges from 15 - 250 for soap making oils and fats. The oils with high-unsaturated fatty acids have low factors while those with low molecular weight saturated acids have high factors. The lathering solubility properties of liquid soap are found to be dependent on the INS factor for the oil or oil blend. Oils and fats with an INS of 130 - 160 are individually unsuitable for liquid soap making on the account of lathering.
INS = saponification value – iodine value (NASCO, 1994). Result is recorded in Table 3.

Physical parameters

Moisture content (M.C.)

The moisture content of oil is expressed as the percentage weight loss when the oil is dried to a constant weight at 110°C. A dry crucible was weighed and the dried oil (5 g) was poured into it. The crucible and content were dried in an oven at 110°C and cooled in a dessicator and weighed. This process was repeated until constant weight was attained. The result is recorded in Table 2.

Refractive index (RI)

The refractive index of oil is a function of molecular structure and impurity. RI provides a quick and easy method to identify oil and determine its purity (Bailey, 1951; Apple White and Bailey, 1985). Abbey refractometer was used and the refractive index determined as explained by Rossel (1971) and the result is recorded in Table 2.

Qualitative determination of saponin

This was done as described by Usher (1984). 1 g of the oil was weighed into a conical flask and 10 ml of distilled water was added and boiled for 10 min. The solution was filtered and 2.5 ml of the

Table 3. Chemical/physical properties of the soap and shampoo.

Property	Liquid soap	Shampoo
Appearance.	Creamy	Creamy
Colour	Pale yellow	Light yellow
Solubility	Very soluble	Very soluble
INS	69.97	69.97
Odour	Pleasant	Pleasant
pH	8.92	9.0
% Free alkali	0.45	0.60

Table 4. Comparative study of the liquid soap and similar products sold in the market.

Property	***B. aegyptiaca*** **seed oil liquid soap.**	Morning fresh	Ultra liquid soap
Appearance	Liquid	Liquid	Liquid
Colour	Light yellow	Green	Light blue
Odour	Pleasant	Pleasant	Pleasant
Solubility in water	Soluble	Soluble	Soluble
% Free alkali	0.45	0.40	0.50

filtrate was added to 1 ml-distilled water in a test tube. The tube was shaken vigorously for 30 s; a honeycomb - like froth was formed which persisted for 30 min.

Formulation of liquid soap

The semi-boiled method was adopted for the formulation as described by Moore (1970). The crude oil (30.0 ml) was poured into a 500 ml round bottom flask to which a solution of KOH (8.2 g) in distilled water (54.5 ml) was added. Ethanol (3.2 ml) was added to the flask and was swirled carefully. The flask was connected to a reflux condenser and refluxed for 40 min over water bath at 85°C. Perfume (2.5 ml) was added at the end of the saponification.

Formulation of shampoo

The shampoo was prepared using the semi-boiled process as in the case of the soap as follows. The crude oil (30.0 ml) was poured into a 500 ml round flask and KOH (7.0 g) dissolved in distilled water (63 ml) was added to the flask. Formaldehyde (0.1 ml) was added and the flask was connected to a reflux condenser and refluxed for 40 min over a steam bath at 85°C. Perfume (2.5 ml) was added at the end of the saponification.

Characterisation of the cleansing agents

The cleansing agents were characterised based on the following parameters

pH

The liquid soap was poured into a clean dry beaker and a standardised pH meter was used to determine its pH as explained by Donkor (1986). The same procedure was adopted for the shampoo. The results are as presented in Table 3.

Alkalinity

This was determined as described by NASCO (1994). The cleansing agents were separately titrated against 0.1 M standardised HCl acid using methyl orange indicator. The result was expressed as percentage free alkali.

$$\%\text{Free alkali} = \frac{V \times M \times 4.7}{SW}$$

Where V = volume of acid, M = molarity of acid, SW = sample weight, 4.7 = conversion factor. Results are shown in Table 3.

RESULTS AND DISCUSSION

Tables 1 - 6 present the chemical and physical properties of the crude oil and the formulated liquid soap and shampoo and similar products sold in the market. The chemical properties of *B. aegyptiaca* seed oil are shown in Table 1. The saponification value of the oil is 168.67 mgKOH/g which is comparable to the values of certain vegetable oils like; sesame, neem, groundnut, palm kernel, castor oils, etc (Table 6). The iodine value (IV) is relatively low, thus the oil is non-drying; a property that make the oil good raw material for the formulation of liquid soap. The peroxide value is also very low, indicating that the oil would be stable (to a large extent), to oxidative degradation. Rancidity begins to be

Table 5. Comparative study of the shampoo and similar products sold in the market.

Property	*B. aegyptiaca* seed oil	Dop	Petals
Appearance	Creamy	Creamy	Creamy
Odour	Pleasant	Pleasant	Pleasant
Solubility in water	Soluble	Soluble	Soluble
pH	9.0	9.2	8.9
% Free alkali	0.60	0.40	0.60
Colour	Light yellow	Yellow	White

Table 6. Analytical properties of some crude vegetable oils and fats used for the manufacture of liquid soap and shampoo.

S/N	Oils/Fats	Refractive index	Saponification value	Iodine value
1	Sesame seed	1.465 – 1.469	167 – 195	104 – 120
2	Neem	1.465	194.5	71
3	Groundnut	1.460 – 1.465	187 – 196	80 – 106
4	Palm kernel	1.460 – 1.472	230 – 254	14.5 – 19
5	Castor bean	1.466 – 1.473	176 – 187	81 – 91
6	Mustard seed	1.461 – 1.469	170 – 184	92 – 125
7	Bone tallow	1.456 – 1.457	189 – 200	31 – 38
8	Coconut	1.448 – 1.450	248 – 265	6.11
9	Olive	1.467 – 1.471	184 – 196	–
10	Soya bean	1.467 – 1.470	188 – 195	120 – 143
11	Palm fruit	1.449 – 1.455	190 – 209	50 – 55
12	Babassis kernel	1.448 – 1.457	245 – 256	10 – 18
13	Balanites kernel	1.4784	168.6	78.7

Source: Rossel, 1971.

noticeable when the peroxide value reaches 20 - 40 meq/kg (Charles and Guy, 1991). The low %FFA reduces the tendency of the oil to undergo hydrolytic 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% (Rossel, 1971). Saponin was found to be present suggesting that the oil can produce lathering products like soap and hair shampoos. The physical properties of the oil are shown in Table 2.

The oil yield was found to be 49.9% indicating that the oil content is high, a factor that is favourable for industrial application of the oil. The moisture content and specific gravity of the oil are very low, therefore its stability is guaranteed. The oil has appealing appearance-golden yellow colour, and it remained liquid at room temperature, thus adding to the good qualities required of industrial oil raw material. The refractive index of the oil also has fallen within the same range with other vegetable oils used to formulate liquid soap (Table 6).

The chemical and physical properties of the crude cleansing agents are as presented in Table 3. The pH of the soap and shampoo are 8.92 and 9.0 respectively, these have fallen within tolerable pH range (6.5 - 9.4) (Poucher, 1984). The percentage free alkali is also very low for the two products. The INS value is very low as was observed, thus the high solubility of the cleansing agents in water and good lathering property. The products are light yellow and they are found to be creamy, this also suggests that the oil can be used for solid soap production.

Tables 4 and 5 present the results of a comparative study of the formulated products and similar products sold in Nigerian markets. As is seen in these tables, the products compare favourably well with products like Dop and Petals shampoo, and morning fresh and ultra liquid soaps sold in Jemita market in Adamawa State of Nigeria in terms of nature, colour, odour, solubility and %free alkali.

Similarly, the properties of some crude vegetable oils used for the formulation of liquid soaps and shampoos are presented in Table 6. From the properties presented it can be seen that *B. aegyptiaca* seed oil competes favourably with the oils already used to formulate liquid cleansing agents.

Conclusion

The seed of this plant has high oil content as was revealed by the % yield (almost 50%). Thus it can be a good source of raw material for many oil based products (soap, shampoo, bio-diesel, lubricants, etc). The oil is non-drying; therefore it may not be a good raw material for paints and related products. The presence of saponin suspected at the beginning of the research was confirmed and its presence has added to the good lathering property of the formulated liquid soap.

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