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Extraction and Evaluation of a Saponin-based Surfactant from Balanites aegyptiaca Plant as an Emulsifying Agent.

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Abstract
The surfactant properties of *Balanites aegyptiaca* (L) plant which has been traditionally identified as a natural surfactant, was evaluated in this work. The defatted surfactant extract from the bark of *B.aegyptiaca* was characterized using FT-IR spectroscopy. IR absorption bands indicate quantitative presence of saponin in the extract. Evaluation of the surfactant properties of *B. aegyptiaca* bark extract was carried out by measuring the emulsion formation/capacity. This was carried out at different concentrations (1g/dm^3, 2g/dm^3, 4g/dm^3), with a comparative study using same concentrations of OMO (a commercial/synthetic surfactant manufactured by Lever Brothers Nigeria). Emulsion formation/capacity of the *B. aegyptiaca* bark extract show better creaming behaviour than OMO. Creaming stability decreases in both surfactant, but more rapidly in commercial detergent. Within 1 and 48 hours, the emulsion formation/capacity for 1 g/dm^3 gave 99.2 % - 76.7 % and 88.3 % - 60.8 %, 2 g/dm^3 gave 97.5 % - 76.7 % and 88.3 % - 60.0 %, while 4 g/dm^3 gave 98.3 % -77.5 % and 87.5 % - 64.1 % for *B. aegyptiaca* bark extract and OMO respectively. These presents *B. aegyptiaca* bark extract which is a natural surfactant, with higher formation/emulsifying power compared to OMO at different concentrations evaluated. This favourable property is associated with the saponin content of *B. aegyptiaca* bark extract. This work therefore contributively publishes the potentials of *B. aegyptiaca* bark extract as a foaming, emulsifying, wetting and cleansing agent.

Keywords: Balanites aegyptiaca, natural surfactant, saponin, emulsion formation/capacity

1. Introduction

Surfactants are usually organic compound that are amphiphilic**,** meaning they contain both hydrophobic groups and hydrophilic groups. Surfactants carry polar and non-polar group [1]. The conventional surfactant just like many other products is sourced from petroleum and coal. This made this raw material source limited, suggesting the sourcing of surfactant or its raw materials from other sources. Saponin is a kind of these natural surfactants. Many plants produce significant quantities of saponins which have surfactant properties.

Saponins are groups of secondary plant metabolites that are found in abundance in various plants. *Balanites aegyptiaca* is an example of such saponin-containing plants [2]. Saponins are any of various plant glycosides with a high molecular weight that form soapy lathers when mixed and agitated with water. It is used in detergent making, as foaming agents, and emulsifiers [3].

The word ‘emulsion’ comes from the Latin word ‘to milk’, as milk is an emulsion of milk fat and water among other components. Emulsion can also be described as homogenous mixture of polar and non-polar liquids. Oil and water can form different types of emulsion based on the amount of the substances in mixture. These include; oil-in-water emulsion wherein the oil is the dispersed phase and water is the dispersion medium, water-in-oil emulsion wherein water is the dispersed phase and oil is the external phase, and multiple emulsions including water-in-oil-in-water emulsion and oil-in-water-in-oil emulsion [4].

Balanites aegyptiaca is a tree that belongs to the *Balanitsceae* family of plants. Its English name is desert date. It is popularly known and called ‘Adua’ in Hausa [5]. There are about twenty five (25) known species of the plant widely distributed from tropical Africa to Burma [6]. It is a drought-resistance tree in the arid regions. It is believed that *Balanites* was the source of some ingredients of the perfume (spikenard) used by the Egyptian royalty [1]. Manji *et al.*, [6] describe *Balanites aegyptiaca* as a savannah tree that can grow as high as 6m. It has a spherical crown and strangled mass of long thorny branches. The leaves are sub sessile or shortly petiolate, grey green in colour, orbicular, rhomboid or obviate shape, often measuring 3.6-6 by 2-5cm; the apex is acute or rarely obtuse. Spines are simple or very rarely bifurcate up to 5cm long and alternate in the axils. Is a common tall tree in savannah country, readily recognized by its several forms of inflorescence bearing yellow-green bisexual flowers with five long greenish petals, and bear fruits [1]. It is commonly planted even far south of its natural habitat. Its spiny branches make it a good fencing material for cattle-pens for which it is used by pastoral folk in both West and East Africa [7]. The plants habit of suckering adds thickness to any planted barrier.

B. aegyptiaca even though has been of various traditional uses, but has not been well worked on scientifically to ascertain its potentials in both domestic and industrial applications [1]. This study therefore seeks to extract, characterize and evaluate the surfactant properties of *B. aegyptiaca* bark extract, and hence its potentials in the production of surfactants and cleansers.

2. Materials and Methods

2.1 Collection of plant Materials

Balanites aegyptiaca plant in Girei, Girei Local Government Area of Adamawa state, Nigeria was used in this study. Fresh barks of matured plants of B. *aegyptiaca* grown in Girei were collected. These were air dried in a room, ground into powder using pestle and mortar (stainless steel) and stored in screw-capped containers. All the chemicals used were of analytical grade and were not subjected to further purification. The general available cleansing agents, synthetic/commercial detergents were purchased from the market in Jimeta, Adamawa state.

2.2 Method of extraction

The standard method described by Agu and Barminas [8] was used for the extraction. With this, 5 g each of the dried grounded samples were weighed into a thimble and transfer into a soxhlet extractor chamber fitted with a condenser and a round bottom flask containing 200 cm^3 of acetone. This was heated on mantle at 60°C for 3 hours, to exhaustively extract lipid and interfering pigments, after which the solvent was distilled off.

The extract was further defatted by transferring it into another soxhlet extractor fitted to both a condenser and a dried weighed round bottom flask containing 200 cm^3 of methanol, and headed on a mantle at 70°C for another 3 hours. The methanol was recovered by distillation at the end of the extraction, and the extract was transferred into the oven, dried, and cooled in desiccator. The percentage of saponin-based surfactants was calculated as shown below:

$$\% \text{ of } Saponin = \frac{\text{Weight of Saponin}}{\text{Weight of Sample}} \times \frac{100}{1}$$

2.3 Emulsion formation/capacity

The procedure by Agu and Barminas, [8] was adopted. That is 50 cm^3 paraffin oil and 50 cm^3 sample solutions were mixed in a beaker. The mixture was homogenized using an improvised method with a 100 cm^3 glass syringe. This improved homogenization process involved repeated cycles of sucking and rapid expulsion of emulsion from the syringe. This was done to ensure proper droplet break-up until a creamy homogenous emulsion is obtained. Emulsion Capacity is expressed as the amount of oil emulsified and held per gram of sample as given by Padmashree *et al.*, [9];

Emulsion Capacity = X/Y x 100/1

Where X = Height of emulsified layer

Y = Height of whole solution in the syringe

3. Results and Discussion

Figure 1 shows the FT-IR spectra of *B. aegyptiaca* bark extract. The broad band between 3700-3200 cm^{-1} is due to the stretching absorption by OH. Other peaks at 2935.43 cm^{-1}, 1021.84 cm^{-1} and 1622.09cm^{-1} are attributable to C-C overtone, C-O stretching (with sharp peak intensity) and C=O stretching (with strong peak). The presence of these functional groups affirms the presence of saponins in the *B. aegyptiaca* bark extract, as similarly reported by Richard, [1] and Rashidi, *et al*., [10].

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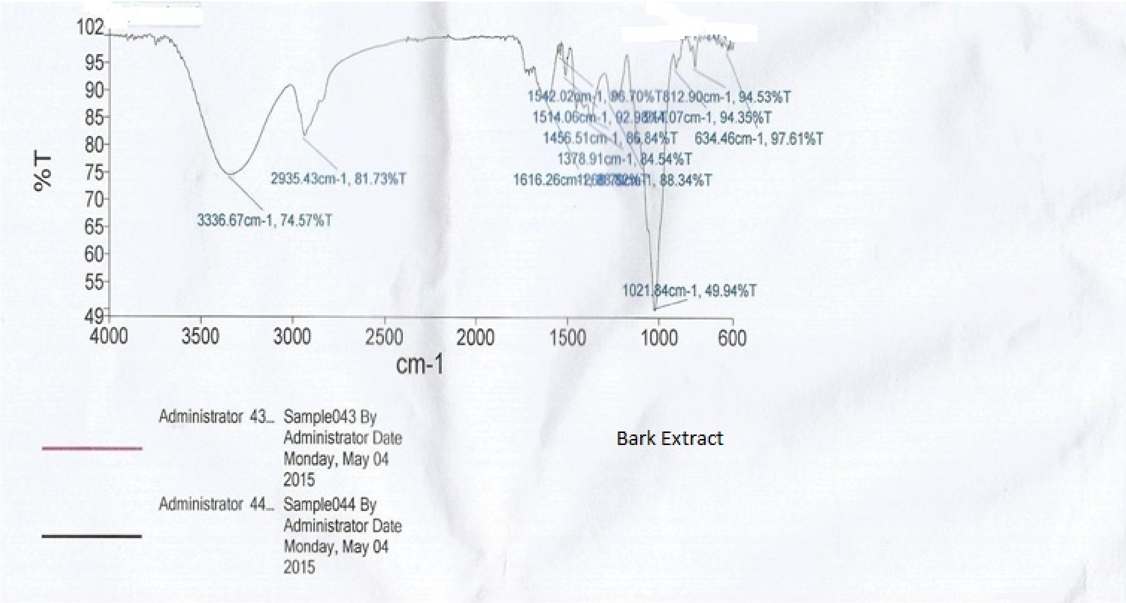

Figure 1: FT-IR Spectra of Extracted Saponin-based Surfactant.

Figure 2 presents and compare the emulsion capacity of 1g of *B. aegyptiaca* bark extract and OMO as function of time. With this quantity, the emulsion formation/capacity of the extract was good (99.2% to 76.7%), and also higher or better compared to OMO (88.3 % to 60.8 %) within the hours of evaluation (1 to 48 hours respectively). This can be attributed to a quantitative presence of saponins in *B. aegyptiaca* bark extract, as saponins has been reported by Agu and Barminas, [8] to be a good emulsifying agent.

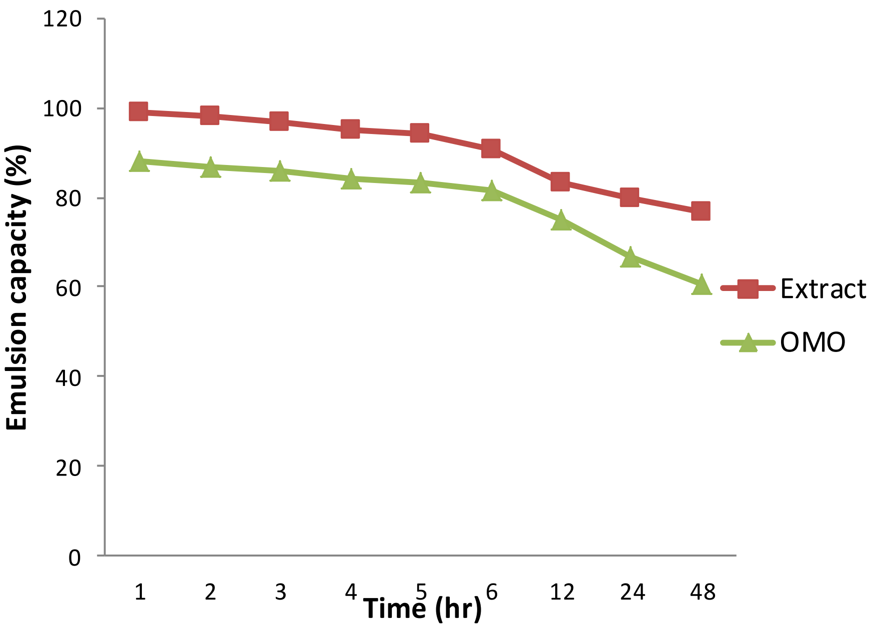

Figure 2: Emulsion capacity (%) versus time (hr) for 1 g of extracted Saponin-based surfactant and OMO solutions.

Figure 3 presents and compare the emulsion capacity of 2 g of *B. aegyptiaca* bark extract and OMO as function of time. The emulsion capacity of *B. aegyptiaca* bark extract (97.5% - 76.7%) is still good and correspondingly higher than that of OMO (88.3% - 60.0%) within the hours of evaluation (1 to 48 hours respectively). However, the emulsion capacity at this higher concentration (2 g) is lower compare to 1 g. This concurs with the report by Kamba et al., [11], that at low soap and detergent concentration, rapid coalescence among the inner and outer droplets to inner phase occurred, resulting in separation within a short period of time.

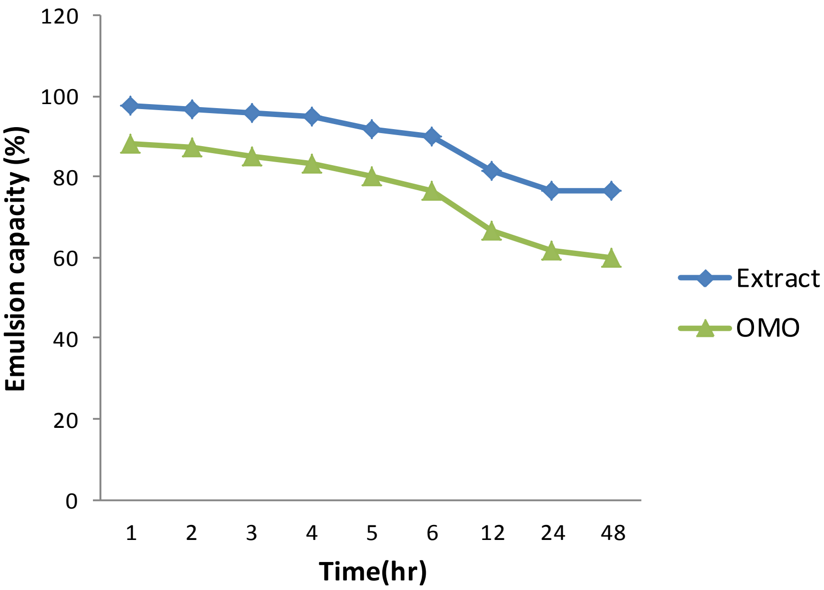

Figure 3: Emulsion Capacity (%) versus time (hr) for 2 g of Extracted Saponin-based surfactant and OMO Solutions.

Figure 4 presents and compare the emulsion capacity of 4 g of *B. aegyptiaca* bark extract and OMO as function of time. At this concentration, the emulsion capacity of *B. aegyptiaca* bark extract (98.3% - 77.5%) remains lower compared to 1 g, and also equate with OMO within the 5th and 6th hour. This further indicates the diminishing emulsion capacity and stability with increase in the concentration of *B. aegyptiaca* bark extract.

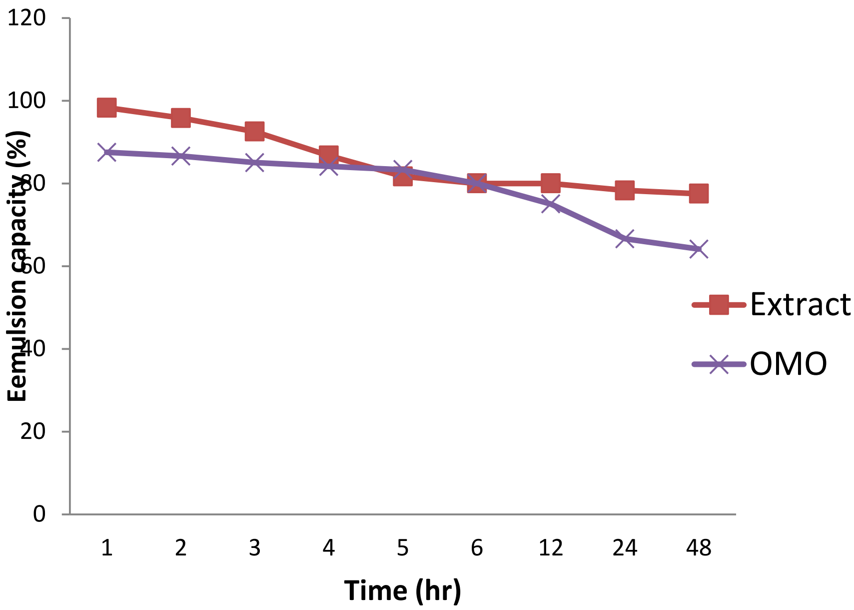

Figure 4: Emulsion capacity (%) versus time (hr) for 4 g of Saponin-based surfactant and OMO solutions.

4. Conclusion

This study has identified *B. aegyptiaca* plants as a source of a saponins based surfactant. The emulsion capacity and stability exhibited by the *B. aegyptiaca* bark extract goes further to recommend its superiority compared to a commercial/synthetic surfactant. The adoption of *B. aegyptiaca* bark extract as basic raw material therefore will further promote greenness as it will be eco-friendly. The use of *B. aegyptiaca* bark extract as recommended in this work will also be economical and conservative, and may also initiate and enlarge profitable agricultural interest in the plant.

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