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Research Article

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Extraction and Evaluation of Foam Formation and Surface Tension of Saponin-Base Surfactants from *Balanites Aegyptiaca* (L) Plant

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Abstract This work evaluates some surfactant properties of *Balanites aegyptiaca* roots and back. Percentage crude extract yield of 73 and 69.1 % was obtained for the roots and bark respectively. The crude extracts were characterized using fourier transformed infrared spectroscopy (FTIR), and the absorption bands indicates the presence of saponins (with widely reported surfactant activities) in the extracts. The foam capacity of these extracts and the surface tension of their solutions were investigated, and these properties were compared with those of a commercial surfactant OMO (a detergent, product of Lever Brothers Nigeria). The extracts exhibits better foam capability compared to the commercial surfactant, while the surface tension of their solutions are only comparable with that of the commercial surfactant at low concentration. Further purification and modifications may however improve the lagging properties of the crude surfactant, thereby presenting it as a sustainable source of an environmental friendly raw material for the surfactant industries.

Keywords Balanites aegyptiaca, saponin-base surfactant, foam production, surface Tension

1. Introduction

Desert date with the botanical name *Balanites aegyptiaca* belongs to the family Balanitsceae. About twenty five known species of the plant are widely distributed through tropical Africa [1]. *Balanites aegyptiaca* has been comprehensively described by Manji et al [1] and Richard [2], as well as reviewed in our previous study [3]. When mature, it is a drought-resistant tree in the arid regions, this therefore has drawn human attention to it, and hence it's reported utility history [2]. Of interest to us in our line of research are its surfactant properties. *Balanites aegyptiaca* even though has the history of traditional use as a cleanser, has not been efficiently investigated to obtain data and information that will present it as a raw material with potentials in surfactant production.

The term surfactant was coined by Antara Products in 1950. They are usually organic compounds that are amphipathic, as they contain both hydrophobic groups ("tails") and hydrophilic groups ("heads"). They therefore are soluble in both organic solvents and water [4]. Surfactants possess surface-active properties which approves them such functions as wetting, cleaning, rinsing and/or fabric softening, hence their typical inclusion in the formulation recipe of detergents and soaps [5]. In the field of pharmaceutical sciences, surfactants are used as emulsifiers, wetting agents, solubilizers etc. Surfactants are mostly derived from petroleum but some may be from natural fats or sugars [4]. Surfactants have also been reported to belong to a group of chemicals of high environmental relevance due to their large production volumes [5]. The dangers posed by the synthetic surfactants to the environments therefore suggest the search for safer products.

The local sourcing of *Balanites aegyptiaca* inclined this study towards sustainability, while its natural sourcing inclined the study towards green production. In furtherance to our previous study [3], this study therefore seeks to investigate some other surfactant properties of the extracts from the roots and bark of *Balanites aegyptiaca* to more comprehensively report its potentials as a surfactant, and its use in the production of cleansers.

2. Materials and Methods

2.1. Collection of sample and Materials

Fresh bark and roots of matured plants of *B. aegyptiaca* grown in Girei were collected randomly. These were air dried at room temperature, grounded into powder using pestle and mortar (stainless steel) and stored in screw-capped containers. Acetone and methanol were analytical grade, and products of the British Drug House. Paraffin oil and OMO are purchased from Yola market in Adamawa state, Nigeria. Materials were not subjected to further purification.

2.2. Method of extraction

The standard method described by Agu and Barminas [6], was used for 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. Foam capacity

Ross-Mile method as described by Azab [7] was adopted. In this method, the foam production is measured by the height of the foam produced. The surfactants solutions were prepared at different concentrations (0 - 3 g/dm^3). 2 cm^3 of surfactant solutions from the burette is allowed to run into a glass tube clamped with a ruler (with length graduations in cm) referred to as the receiver. The height of the foam formed in the receiver was immediately measured. This study is carried out in triplicate, and the average result is reported.

2.4. Surface tension measurement

The surface tension was measured using the drop weight method by Agu, [8], with some modifications as follows; a burette was clean with detergent and was thoroughly rinsed with distilled water. This was allowed to dry before being clamped with its tap turned off. The burette was filled with distilled water. A pre-weighed10 cm^3 measuring cylinder was clamped below to receive the droppings from the burette. The burette was then opened and adjusted at a regular drop wise interval of 2 seconds. Drops were collected up to a total volume of 2 cm^3. The time taken to obtain this was recorded using a stop watch and the weight of the liquid was obtained. During this experiment, the pressure was kept constant by blocking the burette top with a tissue paper to limit the influx of air, thereby stabilizing the rate of flow of the liquid. This was repeated for all the surfactants at different concentrations (0.01, 0.03, 0.06, 0.1, 0.3, 0.6, and 0.8 mg/dm^3). Averages of triplicate determinations were recorded. All analysis were carried out at room temperature, and the surface tension was calculated using the formula below:

$$(r_2) = r_1 n_1 p_2 / n_2 p_1$$

Where r_2 = surface tension of sample

r_1 = surface tension of distilled water (standard solution)

n_1 = Number of drops of water

n_2 = Number of drops of samples

p_1 = Density of water

p_2 = density of sample

A surface tension of 72.13 Nm^{-1} was adopted for distilled water, taken as the standard solution at 25 °C.

2.5. FTIR Analysis

The infra-red (IR) analysis of the extracts were carried out using infra-red spectrophotometer (Buck Scientific Inc, CT USA, Model M500) between 600 to 4000 cm^{-1}.

3. Results and Discussion

With the method used, the crude extract yield was calculated to be 73 and 69.1 % for the roots and bark respectively. This variation in yield can be attributed to the different fibrous nature of the plant's parts.

3.1. Characterization of surfactants

Figure 1 shows the FTIR spectra of the extracts from the bark and roots of *B. aegyptiaca*. The broad band between 4000 and 3000 cm^{-1} in both spectra is due to the O-H stretching band. Peaks at 2935.43 cm^{-1} and 2929.97 cm^{-1}, 1021.84 cm^{-1} and 915.03 cm^{-1} and the small peaks at 1622.09 cm^{-1} and 1634.68 cm^{-1} on the back and roots extracts respectively, can be respectively attributed to C-C overtone, C-O stretching bands and C=O stretching bands. The functional groups identified in these spectra infer the presence of saponins in the extracts. This can be held responsible for the foaming properties of the extracts [9]. Spectra obtained in this study are similar, and consistent with the one obtained in our previous work [3].

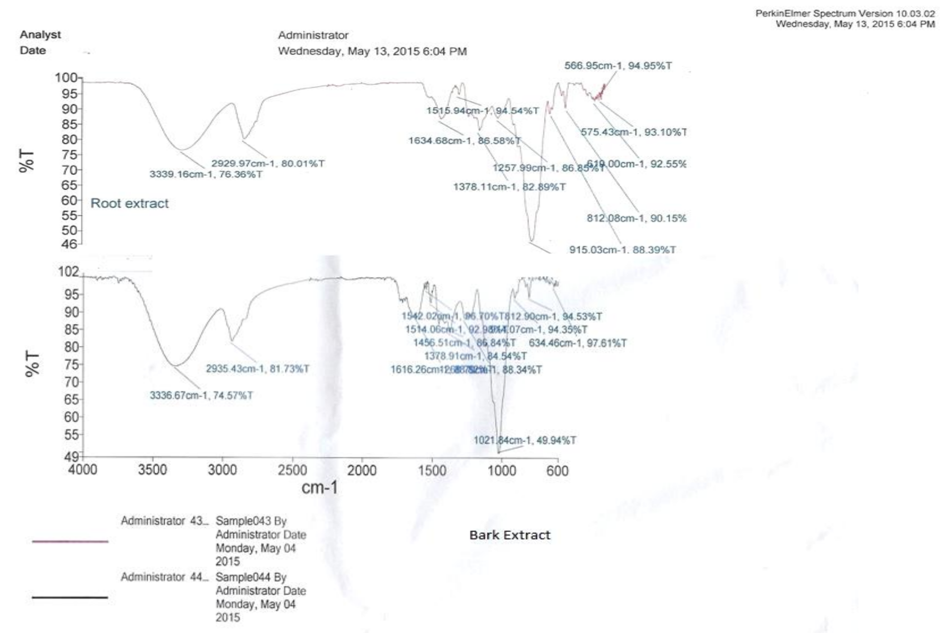

Figure 1: FTIR Spectra of B. aegyptiaca bark and roots extracts

Foam (produced by agitated surfactant) is the metastable systems occurring at the liquid-air interface [10]. Figure 2 presents and inter-compares the foam capacity of the root extract, back extract and OMO. Both extract exhibits higher foam capacity compared to OMO, while the back extract tends to be rising higher than the root extract as the concentration increases. This can be attributed to the saponins content of the extracts and variation in such factors as the critical micelle concentration (CMC), specific molecular features of the surfactant, ionic strength and pH of the surfactant solutions [11].

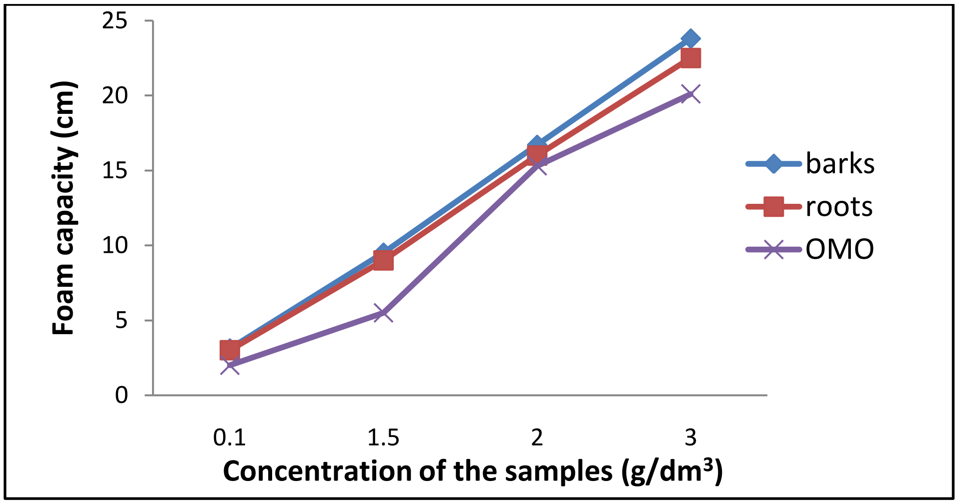

Figure 2: Effect of concentration on the foam capacity of surfactants

3.2. Surface Tension

Figure 3 shows and compares the surface tension of different concentrations (g/dm^3) of the extracts and OMO at 30 ^oC (room temperature). The surface tension as expected generally decreases for the surfactants as the concentration increases. However, it decreases more rapidly with OMO stating from 0.06 g/dm^3, while the extracts averagely show similar properties. The reduction of surface tension by surfactants allows the liquid to have a more efficient contact with materials hence a better cleansing power. Therefore, at correspondingly low concentrations, the crude extracts may exhibit cleansing power comparable with OMO. The dragging drop in surface tension of the extracts' solutions at higher concentrations can be attributed to poor solubility of the extracts [12], and this may be due to the presence of impurities. However, this may be improved on further purification of the extracts. Results obtained here is comparable to that reported by Agu et al. [13].

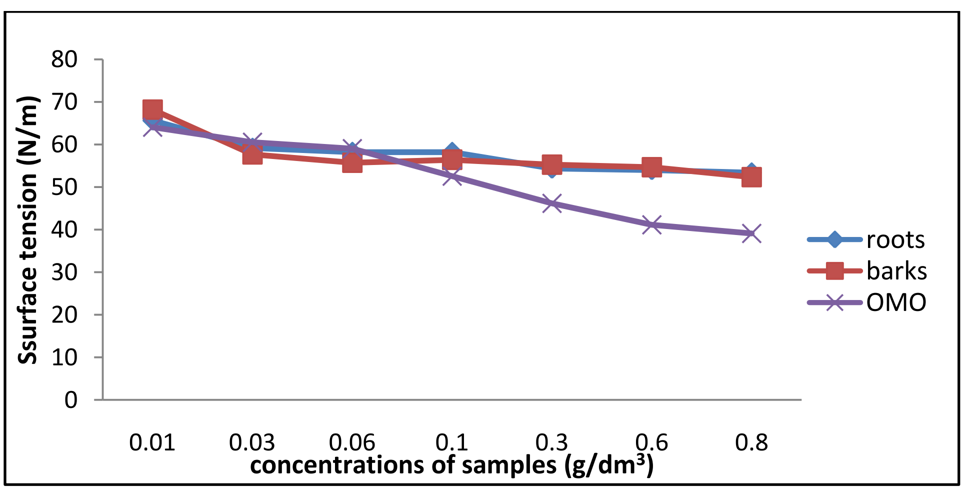

Figure 3: Surface Tension of saponins-base Surfactants and OMO at Various Concentrations (g/dm^3) at 30 ^oC

4. Conclusion

The investigation carried out in this study on the surfactant properties of crude extracts of *balanites aegyptiaca* has infer its industrial potentials in the production of soap and/or detergents from a green source. Some of the investigated properties (which is in furtherance to our previous work in Bintu et al., 2015) [3], which are again competitively comparable with those of a finished (synthetic) commercial surfactant (OMO), has presented a convincing report. However, further processing, purification, and modification of this crude product will surely made it better hence providing an alternative (to petroleum), more local, wider, cheaper, and greener raw material sourcing for the surfactant industries in favour of both green production and sustainability.

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