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Extraction and Evaluation of a Saponin-base Surfactant from *Cissus populnea* Plant as an Emulsifying Agent

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Authors' contributions

This work was carried out in collaboration between all authors. Author IIN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JTH and JEE managed the analyses of the study. Author MH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The surfactant properties of *Cissus populnea* plant which has been locally recognized as a natural surfactant was assessed in this work. The defatted surfactant extract from the leave, root and stem-bark of *Cissus populnea* was characterized using FTIR spectroscopy. IR absorption bands indicate the quantitative presence of saponin in the extract. Determination of the surfactant properties of *Cissus populnea* leaves, root and the stem-bark extract was done by measuring the emulsion formation/ capacity. This was done at different concentration (1 g/dm^3, 2 g/dm^3, 4 g/dm^3). The results obtained were compared using same concentrations of OMO (a commercial/synthetic surfactant manufactured by lever Brother Nigeria). Emulsion formation/capacity for of the *Cissus populnea* leave, root and stem-bark extract show better emulsification characteristics than OMO. Creaming stability decreases in all the surfactant, but more rapidly in commercial detergent. Within 1 and 48 hours, the emulsion formation/ capacity for 1 g/dm^3 gave 97.3% - 67.1%, 92.0% - 72%,

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77.0% - 58.3%, 88.3%, 2 g/dm^3 94.2% - 70.0%, 90.5% - 80.3%, 80.2% - 53.3%, 88.3% - 60.0%, while for 4 g/dm^3 gave 90.63% - 68.3%, 98.0% - 50.3%, 91.3% - 66.7%, 87.5% - 64.1% for *C. populnea* leave, root and stem-bark and OMO respectively. The FTIR absorption band at 2364.04 cm^{-1} and 2922.49 cm^{-1}, 2364.50 cm^{-1} and 2316.86 cm^{-1} and the small peaks at 1008.89 cm^{-1} and 1045.77 cm^{-1} on the leave, root and stem-bark extracts respectively, were suggested to C-H stretching, C=C stretching bands and C-O stretching peak and the carboxyl group at 1734.59 cm$^{-1,}$ 1615.13 cm^{-1} for crude and extracted saponin respectively. These present *C. populnea* leave, root and stem-bark extract which is a natural surfactant, with higher formation/emulsifying efficiency compared to OMO at different concentration evaluated. This favourable characteristic is associated with saponin content of *C. populnea* leave, root and stem-bark extract. This work therefore contributively explored the potentials of *C. populnea* extract as a foaming, emulsifying, wetting and cleansing agent.

Keywords: Cissus populnea; natural surfactant; saponin; emulsion formation/capacity.

1. INTRODUCTION

Surfactants are mostly organic compounds that are amphiphilic, implying they contain both hydrophobic groups and hydrophilic groups. Surfactants possess polar and non-polar groups [1,2]. Richard [1] and Kime et al. [2] reported that Conventional surfactants just like much other products are derived from petroleum and coal. This made the 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 the various plants. *Cissus populnea* is an example of such saponin-containing plants [2,3]. Saponin is an example glycoside found in a plant with a higher molecular weight that forms soapy lathers when mixed and shaken with water. It is used in detergent making, as foaming agents and emulsifiers [3].

Ahmed et al. [4] reported that the word 'emulsion' comes from the latin 'to malk', as milk is an emulsion of milk fat and water among other components. Emulsion can also be described as homogeneous mixture of polar and non –polar liquids. Oil and water can form different types of emulsion based on the amount of the substances in the mixture. This include; oil-in-water emulsion wherein water 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.

Cissus populnea belongs to the family of *Amplidacea (vitacea*) as confirmed by [3], which are woody climbers, sometimes vines, rarely small succulents' trees, and hermaphrodite or polygamoneacious to polygamodroecions. Cissus *populnea* grows in divers' ecozones of Nigeria, Uganda, Niger Republic, Cameroon and Coted'voire [5]. The plant is climbing stem, widely distributed in many parts of Nigeria, especially within the guinea savannah region of Anambara, Kogi and Benue States [6]. The Igala and Idoma ethnic group refers to this plant as Okoho, Yorubas as Ogholo, and Hausas as dafaaraa. It is used extensively in medicinal preparation in West Africa.

All part of *Cissus populnea* exudes, a mucilagninous material is traditionally utilized as a raw material [7]. Gum exudates are mainly obtained from the stem and root of the plant. The gum obtained from *Cissus populnea* has been evaluated for it potential use as a dispersants in pharmaceuticals liquid system [8]. The root extract from the plant have been use for treatment of skin diseases, boils, infected wounds and for treating urinary tract infections, thus suggesting antibacterial potency of the of the plant [9]. In Ghana, the plant is used as diuretic and as a post-harvest ethnobotanical protectant [10].

Cissus populnea has been used for various traditional uses, but has not been well researched on scientifically to assess its potentials in both domestic and industrial applications. This study was conducted to extract, characterize and evaluate the surfactant properties of *Cissus populnea* leave, roots and stem-bark extracts, and hence its potentials in the manufacture of surfactants and cleansers.

2. MATERIALS AND METHODS

2.1 Collection of Samples (Plant Materials)

Cissus populnea plant in Michika, Michika Local Government Area of Adamawa state, Nigeria was used in this study. Fresh leave, root and stem- bark of *Cissus populnea* grown in Michika were collected on 4th December, 2016. These were air dried at a room temperature, grinded into fine texture 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 generally available cleansing agents, synthetic/ commercial detergents were bought from the market in Jimeta, Adamawa state.

2.2 Method of Extraction

The standard procedure described by Agu and Barminas [11] and Kime et al. [2] was employed for the extraction. 5 g of each of the dried grinded sample was 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 the heating mantle at 60°C for 3 hours, to completely extract lipid and interfering pigments, then the solvent was distilled off. The extract was further defatted by transferred into another Soxhlet extractor fitted to both a condenser and a dried weighed round bottom flask containing 200 cm^3 of methanol applied under 60°C using a heating mantle and completely extracted for another 3 hours. The methanol was recovered by distillation at the end of the extraction and transfers the flask with its extracts to the oven to evaporate to dryness before cooling in a desiccator. The percentage of saponin-based surfactants was calculated as shown below:

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

2.3 Emulsions Formation/Capacity

Emulsion formation/capacity was carried out according to the procedures described by Kime et al. [2]. That is, 50 cm^3 sample solutions were mixed in a beaker. The mixture was homogenized using an improved method with a 100 cm^3 glass syringe. This improved homogenization process involved continuous cycles of sucking and rapid expulsion of the emulsion from the syringe. This was carried out to ensure proper droplet break-up until a creamy homogenous emulsion was formed. Emulsion capacity is express as the amount of oil emulsified and held per gram of sample.

Emulsion Capacity = X/Y x 100/1

Where,

X = Height of emulsion layer
Y = Height of whole solution in the syringe

2.4 Fourier Transform Infrared Spectroscopy

The FTIR spectra were used to obtain information on the chemical structure of the various extract. Fourier transform infrared data was obtained using the Perkin Elmer, GX spectrum model with wavelengths ranging from 4000-400 cm.

3. RESULTS AND DISCUSSION

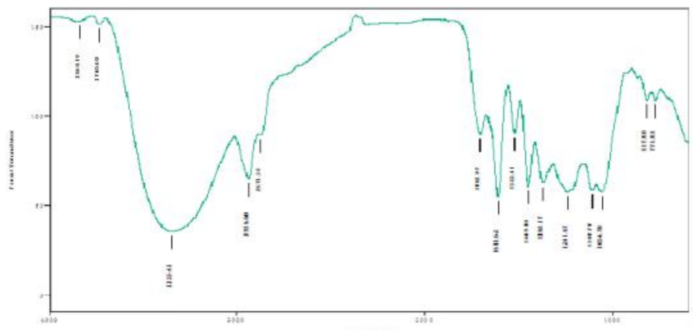
Fig. 1 shows the FT-IR spectra of crude surfactant and extracted saponin from the leave, roots and stem-bark of *Cissus populnea*. The broad band between 4000 and 3000 cm^{-1} in all the spectra suggested OH stretching with broad peak intensity. The position of absorption band at 2364.04 cm^{-1} and 2922.49 cm^{-1}, 2364.50 cm^{-1} and 2316.86 cm^{-1} and the small peaks at 1008.89 cm^{-1} and 1045.77 cm^{-1} on the leave, root and stem-bark extracts respectively, were suggested to C-H stretching, C=C stretching bands and C-O stretching peak and the carboxyl group at 1734.59 cm^{-1}, 1615.13 cm^{-1} for crude and extracted saponin respectively. The functional groups detected and identified in these spectra indicate the presence of saponins in the extracts. This accounts for the foaming properties of the extracts as similarly reported by Rechard [1]; Rashidi et al. [12] and Kime et al. [2].

Sample filename	Leaf extract.spc
File Title	11/17/2016 11:46:33 title
Date	Thu Nov 17 11:52:18 2016

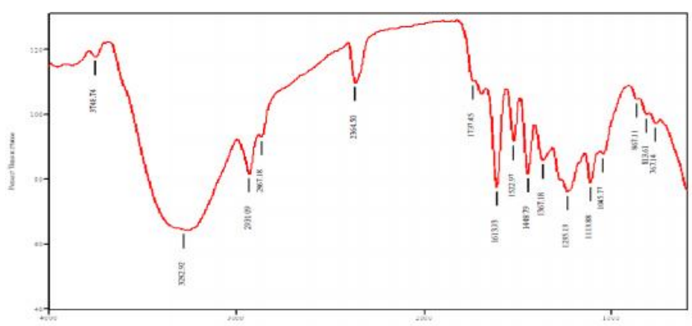
Fig. 2 present and compare the emulsion capacity of 1 g of *C.populnea* leave, root and steam-back extract OMO as a function of time. With this quantity, the emulsion formation/capacity of the extract was good (97.3% to 67.1%), (92.0% to 72.3%) and also higher or better compare to OMO (88.3% to

60.8%) and stem-bark (77.0% to 58.3%) within the hours of evaluation (1 to 48 hours respectively). This can be attributed to a quantitative presence of saponins in *C. populnea* leave, roots and stem-bark extracts, as saponins has been reported by Agu and Barminas [11] and Kime et al. [2], to be a good emulsifying agent.

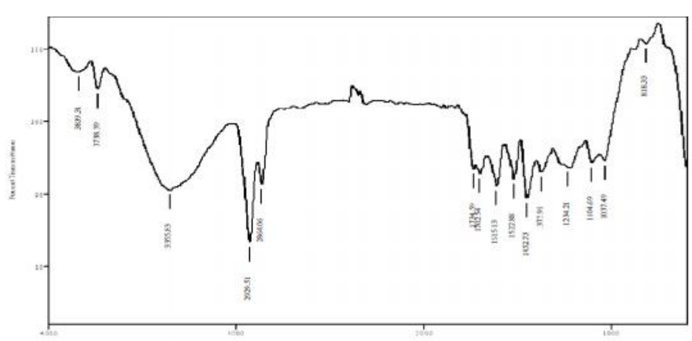
Fig. 3 presents and compare the emulsion capacity of 2 g of *C. populnea* leaves, roots, stem-bark extract and OMO as a function of time. The emulsion capacity of *C. populnea* leave, roots and stem-bark extract (94.2% to 70.0%), (90.5% to 80.3%) is still good and correspondingly higher than that of OMO (88.3% to 60%) and stem-bark (80.2% to 53.3%) within the hours of evaluation (1 to 48 hours respectively). However, the emulsion capacity at this higher concentration (2 g) is lower compared to 1 g. This concurs with the report by Kime et al. [2] 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.



Leave extract



Root extract



Stem-bark extract

Fig. 1. FT-IR spectra of extracted Saponin- base surfactant

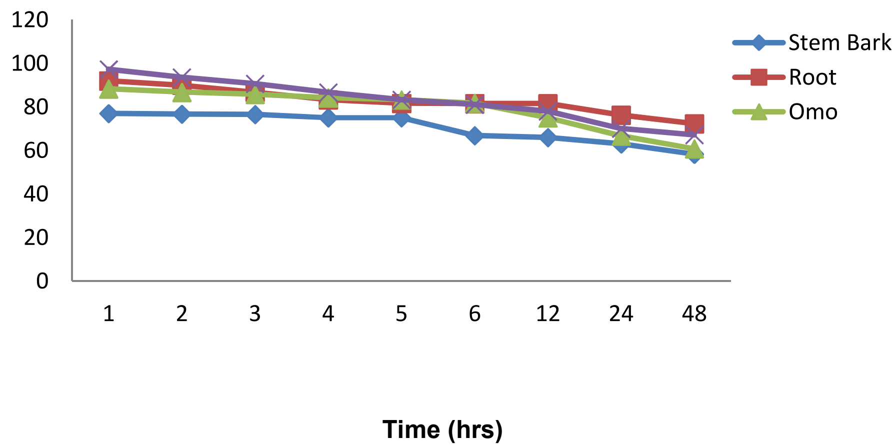


Fig. 2. Emulsion capacity (%) Versus Time (hr) for 1 g of Extracted Saponin-based Surfactant and OMO solution

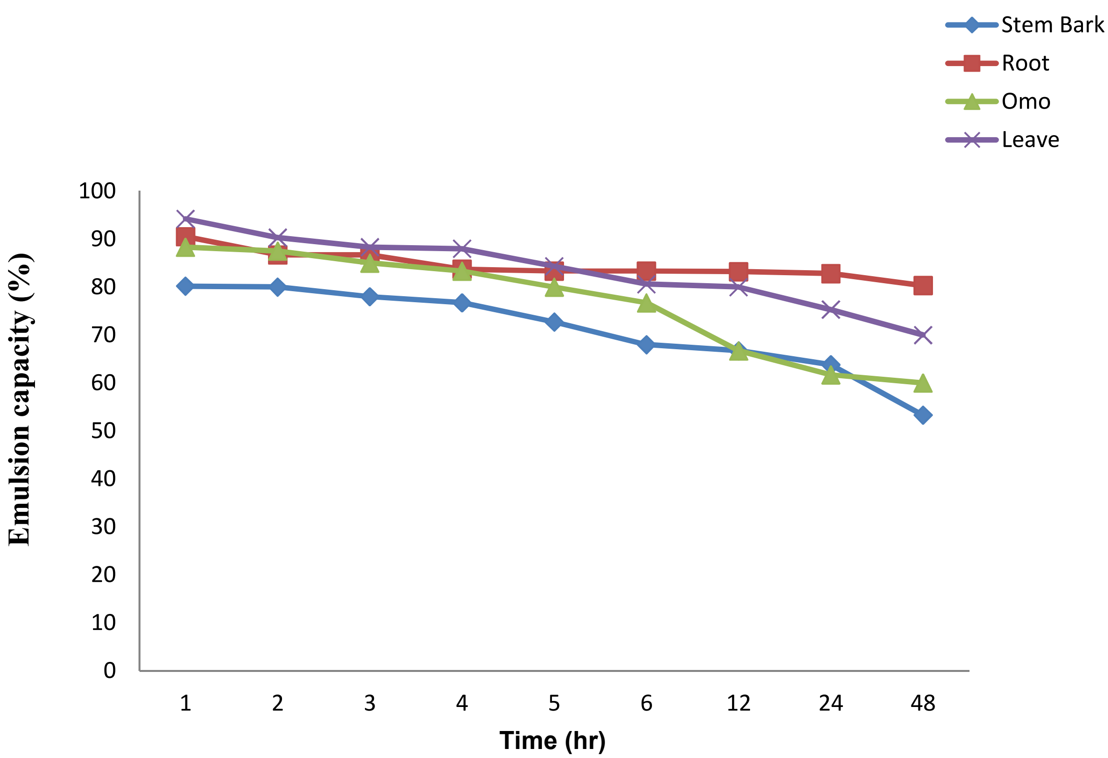


Fig. 3. Emulsion capacity (%) Versus time (hr) for 2 g of Extracted Saponin-based Surfactant and OMO Solution

Fig. 4 presents and compare the emulsion capacity of 4 g of *C. populnea* leaves, roots, stem-bark extract and OMO as a function of time. At this concentration, the emulsion capacity of *C. populnea* leave, roots and stem-bark extract (90.6% to 68.3%), (98.0% to 50.3%) and stem-bark (91.3% to 66.7%) remains lower compared to 1 g. The leaves were also equated with roots within the 3th and 5th hours while OMO decreases. This further indicates the diminishing emulsion capacity and stability with an increase in the concentration of *C. populnea* leaves, root and stem-bark extract as reported by Kime et al. [2].

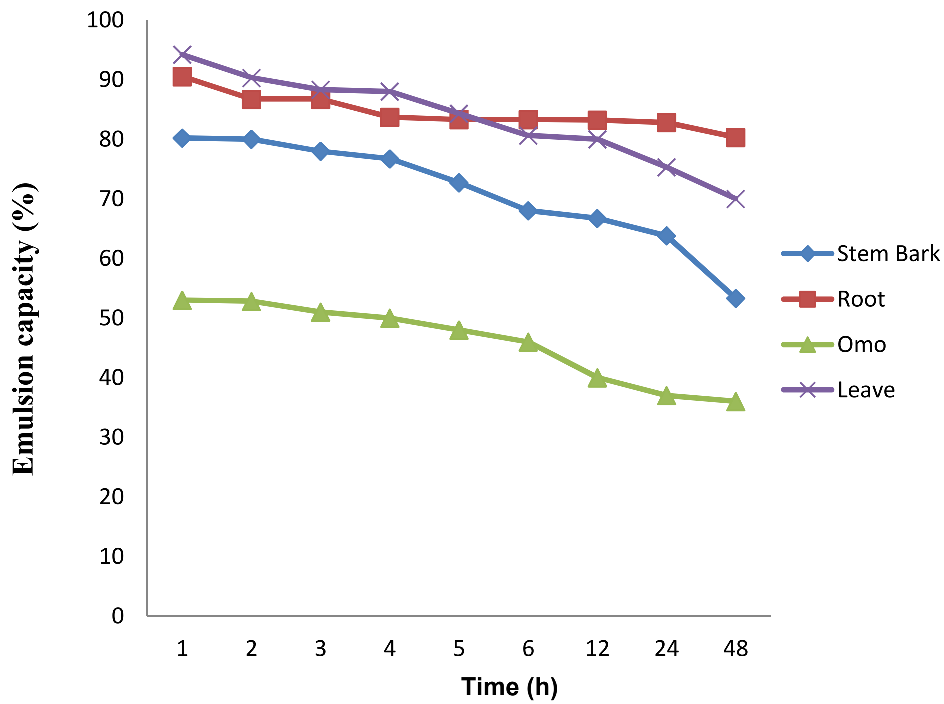


Fig. 4. Emulsion capacity (%) versus time (hr) for 4 g of extracted saponin-based surfactant and OMO solutions

4. CONCLUSION

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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