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Emulsification Potential and Phytochemical Profile of *Jatropha tanjorensis*

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ABSTRACT

Background and Objective: The use of plants has been validated for its numerous benefits in medicine, industries, nutrition, etc. The emulsifying and demulsifying ability of *Jatropha tanjorensis* leaves extracts in oil-in-water was investigated. **Materials and Methods:** The N-hexane, ethanol, and distilled water extracts were prepared using the bulk maceration method and Soxhlet apparatus. Phytochemical analysis of the plant extracts was done by the GC-MS method. **Results:** The results obtained revealed the presence of bioactive compounds, including tannins and terpenoids in the hexane extract, tannins, saponins, flavonoids, alkaloids, anthraquinones in the ethanol extract, saponins and alkaloids in the distilled water extract. Emulsification tests with the different extracts were done, using the volume of water separated as the yardstick. The resmixture, though the ethanol extract gave a better result. The n-hexane extract, on the other hand, demulsified the mixture. **Conclusion:** The emulsification and demulsification results were better at higher concentrations of the extract, and were attributed to the surfactant phytochemical compounds present in the extracts.

KEYWORDS

Jatropha tanjorensis, water in oil, ethanol, hexane, distilled water, synthetic, emulsifier, surfactants

INTRODUCTION

Emulsions are colloidal systems consisting of two or more immiscible liquids, in which one is dispersed in the other. They are formed through a process known as emulsification, which is aided by emulsifying agents (emulsifiers). Emulsifiers are surface-active agents that stabilize immiscible dispersions like oil and water. They act by permitting the mixing of two or more dissimilar liquids and preventing individual separation of the liquids. Emulsifiers are also known as surfactants[1].

Surfactants are surface-active agents characterized by a hydrophilic (water-attracting) head, a lipophilic (fat-attracting) region, and a hydrophobic (water-repelling) tail. They reduce the surface tension between fluids and are widely used in the food, pharmaceutical, cosmetic, and other industries for breaking, creating, and stabilizing emulsion-based products due to their emulsifying and demulsifying properties.

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As amphiphilic compounds, surfactants can adsorb at oil-water interfaces, decrease interfacial tension, and form stable emulsions[2,3]. Natural emulsifiers, particularly saponins, serve as effective alternatives to synthetic surfactants in producing oil-in-water emulsions, given that they are biodegradable, less toxic, and readily available[4].

Emulsion stability is encouraged by three major conditions, namely: The presence of immiscible liquids, the existence of an emulsifier or emulsifying agent, and adequate agitation. Factors that affect the stability of an emulsion include: Age of emulsion, viscosity, specific gravity, and water percentage. Abubakar and Aliyu[5] reported that chemicals are unable to resolve an emulsion when they have no dehydrating component, which could result in water separation. Earlier researchers[6] categorized demulsifiers and emulsifiers as ionic and non-ionic surfactants, which may either break an emulsion or prevent an emulsion from resolving. Extracts that can demulsify have been likened to having lower turbidity and sharp interface quality as a result of good dehydrating ability. Researchers in surface materials are working hard for the possible replacement of synthetic emulsifiers with naturally derived emulsifiers, which are biodegradable, renewable, cheap, available, and eco-friendly. Natural surfactants lower interfacial tensions[7,8]. Hence, the investigation of *Jatropha tanjorensis* leaves extracts as a natural emulsifier.

Jatropha tanjorensis, locally known as hospital too far, is a common weed of field crops, a gregarious shrub of about 1.8 m in height. It is usually grown in rainforest zones of West Africa. The plant, as identified, belongs to the family of *Euphorbiaceae.* The phytochemical studies of *Jatropha tanjorensis* revealed that it contains some phytochemicals such as alkaloids, flavonoids, tannins, cardiac glycosides, anthraquinones, and saponins.

The effect of chemical breaking agents on water in crude oil emulsion systems using natural, polyhydric alcohol, and amine groups serving as demulsification agents of a stable emulsion has been reported[9]. They reported that the efficiency of a demulsifier depends on two factors which are the solubility of the demulsifier either in water or oil molecular weight. Previous study[10] investigated the separation of oil in water emulsion during chemical recovery operations using a known surfactant, N-octyltrimethyl ammonium bromide, as the demulsifier at concentrations between 200 to 300 ppm. Their result showed a decrease in oil content from 550 to 70 ppm after 4 hrs. Another research[11] demonstrated that formulated blends of demulsifiers give better results than the single ones. This research aimed at investigating the emulsification potency of *Jathropha tanjorensis* leaves extracts by characterizing different solvents extracts of the leaves and measuring the volume of water droplets from the oil–water solution.

MATERIALS AND METHODS

Study area: This study was carried out in the Department of Chemistry Laboratory, Rivers State University, Port Harcourt, Nigeria, between May to July, 2024.

Collection of plant materials and chemicals: *Jatropha tanjorensis* leaves were collected from Atali farm, Obio/Akpor Local Government Area, Rivers State, Nigeria. It was identified by a taxonomist. The crude oil sample was obtained from Ahoada Local Government Area, Rivers State, Nigeria. Dichloromethane (DCM), distilled water, n-hexane, and methanol were obtained from the Department of Chemistry, Rivers State University laboratory, Nigeria.

Extraction and preparation of plant extracts: The leaves of the *Jatropha tanjorensis* tree were plucked, washed with distilled water, air dried, and ground into fine powder. Two methods of extraction were employed: Extraction by maceration (for the distilled water extract) and extraction using a Soxhlet apparatus (for the n-hexane and ethanol extracts). Ethanolic extraction yielded deep green extracts, while n-hexane extraction yielded pale green extracts. The extracts were characterized using GC-MS[12].

The emulsifiers were prepared by mixing 10 g of each of the extracts with 20 mL of dichloromethane.

Emulsification test: About 500 mL of crude oil and 250 mL of water were homogeneously mixed to form an emulsion. 10 mL of the mixture was transferred into six centrifuge tubes calibrated with 15 mL each. Into the 10 mL of the oil in water mixture contained in the centrifuge tube, 1 mL of the ethanol, hexane, distilled water extracts, and synthetic emulsifiers were added, respectively, and placed in a tube rack for 60 mins. The tests were carried out at an optimal concentration of 3000 ppm of the solution. At 10 min intervals, readings were taken for each solvent extract, respectively. The synthetic emulsifier used was glycerine.

RESULTS

The chromatograms of the distilled water, ethanol, and hexane extracts of *Jatropha tanjorensis* are as shown in Fig. 1, 2, and 3, respectively. The spectra reveal the compounds detected when analyzed using GC-MS. Details of the compounds on the spectra are shown in Tables 1, 2, and 3.

Table 1 presents the results of the phytochemical screening of the ethanol extract of the plant studied (*Jatropha tanjorensis*). It reveals that the ethanol extracts contain ester, fatty acids, alcohol, amino, and diene compounds with their corresponding percentage composition, with 8-Isopropenyl-1,5-dimethyl-cyclodeca-1,5-diene as the highest in composition (15.144%).

Characterization of the hexane extract reveals that the predominant compounds are (E)-2-Butenylcyclopr96opane (18.407%) and 5.alpha.17.alpha.-Pregnan-20-one-12beta-hydroxyl (16.905%) (Table 2). Other compounds contained in the extract are ethers, fatty acids, esters, and hydroxyls. Table 3 shows the different components of the distilled water extract, with (E0-9-Octadecanoic acid, ethyl ester as the predominant component (28.572%). Other components include esters, fatty acids, alkynes, and trienes. Table 4 shows the summary of the phytochemical compounds present or absent in the different solvent extracts from the leaves of *Jatropha tanjorensis*.

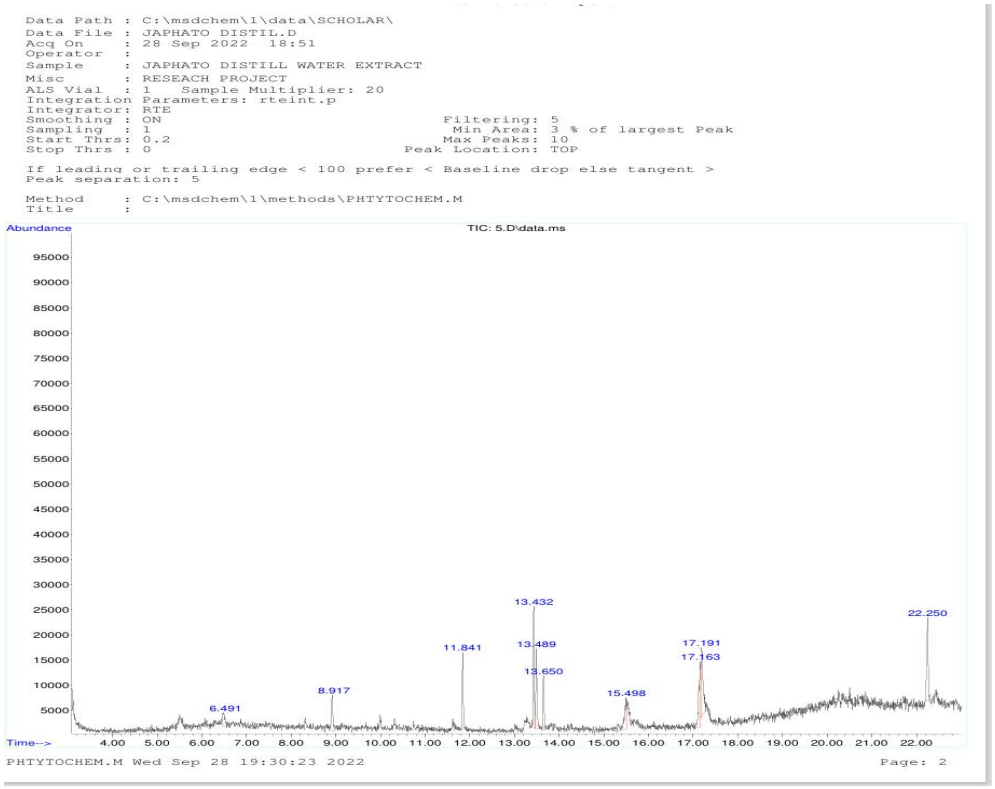


Fig. 1: Chromatograms of the aqueous extract of *Jatropha tanjorensis*

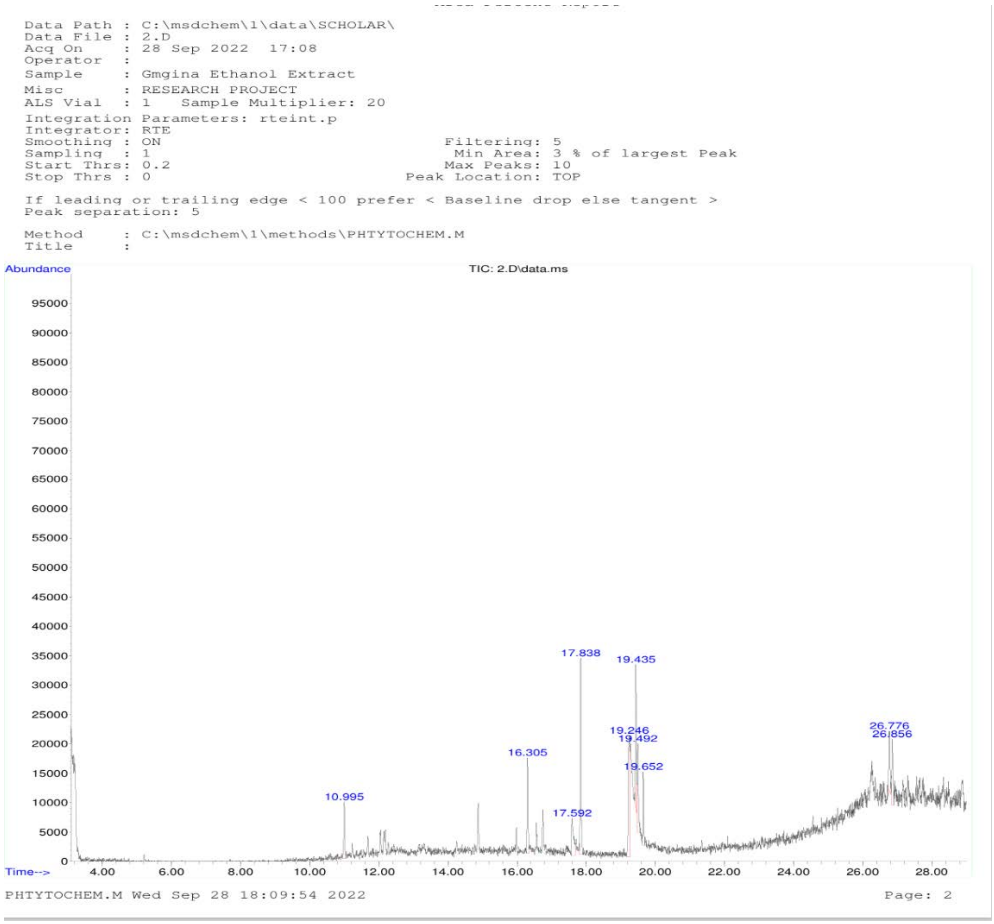


Fig. 2: Chromatograms of the ethanol extract of *Jatropha tanjorensis*

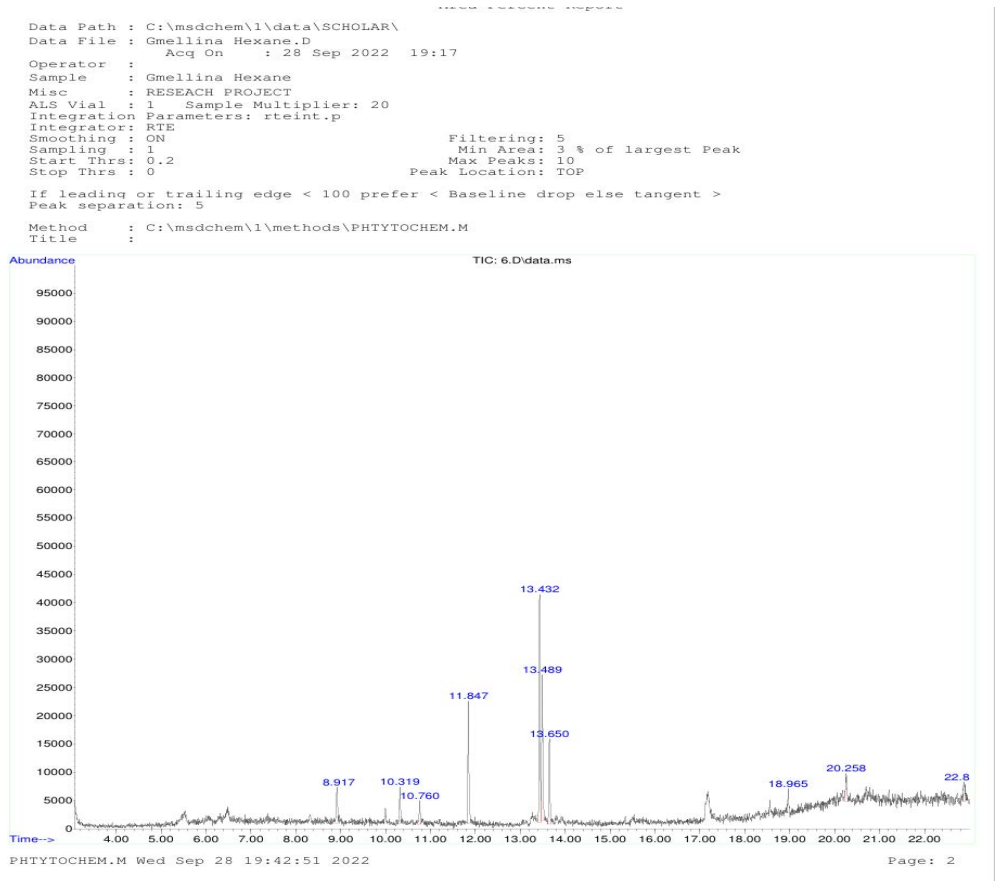
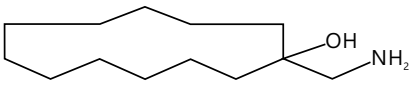
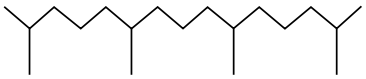
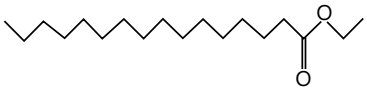
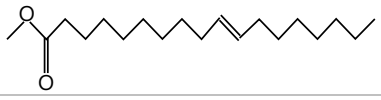
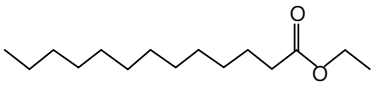
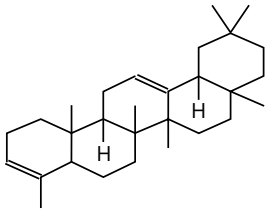
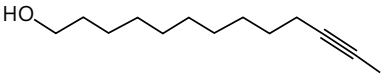
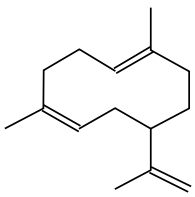
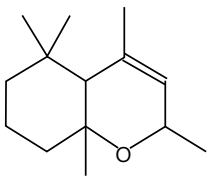


Fig. 3: Chromatograms of the hexane extract of *Jatropha tanjorensis*

Table 1: Major chemical constituents identified through GC-MS analysis of the ethanol extract

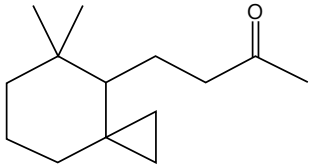
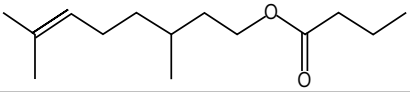
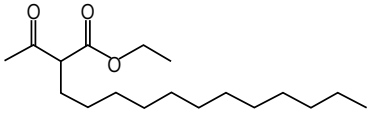
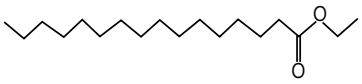
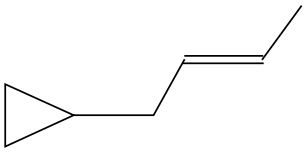
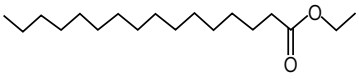
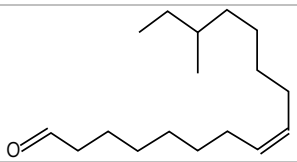
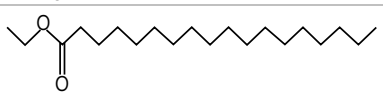
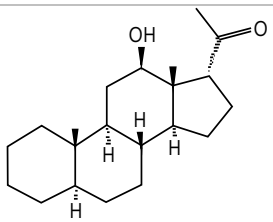
RT	Compound name		Structure	Composition (%)
6.491	Cyclododecanol, 1-aminomethyl- ($C_{13}H_{27}NO$)	213		3.455%
8.917	Pentadecane, 2,6,10,14-tetramethyl ($C_{19}H_{40}$)	268		6.149%
11.841	Hexadecanoic acid, ethyl ester ($C_{18}H_{36}O_2$)	284		9.054%
13.432	trans-9-Octadecenoic acid, pentyl ester ($C_{23}H_{44}O_2$)	352		14.458%
13.489	10-Octadecenoic acid, methyl ester ($C_{19}H_{36}O_2$)	296		11.567%
13.650	Ethyl tridecanoate ($C_{15}H_{30}O_2$)	242		6.481%
15.498	24-Noroleana-3,12-diene ($C_{29}H_{46}$)	394		6.493%
17.163	11-Tridecyn-1-ol ($C_{13}H_{24}O$)	196		13.204%
17.191	8-Isopropenyl-1,5-dimethyl-cyclodeca-1,5-diene ($C_{15}H_{24}$)	204		15.144%
22.250	2,4,5,5,8a-Pentamethyl-4a,5,6,7,8, 8a-hexahydro-2H-chromene ($C_{14}H_{24}O$)	208		13.994%

RT: Retention time (sec)

Table 5 and 6 give the emulsification test results, showing the volume of water droplets in the solution with 1 and 2 mL of the different solvent extracts at different times, respectively. The volume of the water droplet on the blank solution is also presented.

Table 5 shows the volume of water (in mL) separated at six different time intervals (from 10 to 60 min) using 1 mL of various emulsifiers. The blank sample (no emulsifier) exhibited the highest water separation throughout, starting from 3.8 mL at 10 min and reaching a maximum of 5.9 mL at 50 min, indicating no emulsion stability. Ethanol emulsifiers initially showed no water separation up to 30 min but sharply increased to 4.5 mL at 40 min and stabilized at 5.5 mL by 50 min, suggesting moderate emulsion breakdown over time. Hexane emulsifiers showed fluctuating water separation, with small amounts initially (0.8 mL at 10 min), a temporary drop, and then a gradual increase

Table 2: Major chemical constituents identified through GC-MS analysis of the hexane extract

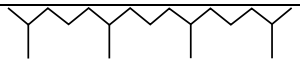
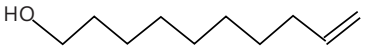
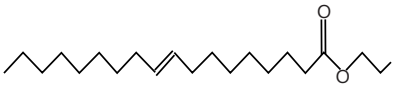
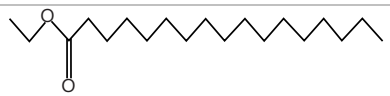
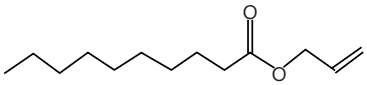
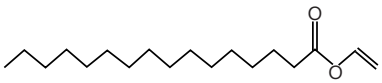
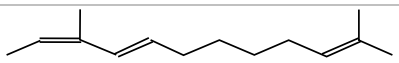
RT	Compound name	MW	Structure	Composition (%)
10.994	Spiro[2.5]octane,5,5-dimethyl-4-(3-oxobutyl)-($C_{14}H_{24}O$)	208		8.765%
14.868	Docosyl octyl ether ($C_{30}H_{62}O$)	438		7.934%
16.299	Citronellyl butyrate ($C_{14}H_{26}O2$)	226		5.586%
17.586	2-Acetyltetradecanoic acid, ethyl ester ($C_{18}H_{34}O_3$)	298		4.818%
17.838	Hexadecanoic acid, ethyl ester ($C_{18}H_{36}O_2$)	284		11.674%
19.068	Butenylcyclopropane (C_7H_{12})	96		18.407%
19.434	trans-9-Octadecenoic acid, pentyl ester ($C_{23}H_{44}O_2$)	352		12.361%
19.486	(Z)-14-methylhexadec-8-enal ($C_{17}H_{32}O$)	252		8.465%
19.652	Octadecanoic acid, ethyl ester $C_{20}H_{40}O_2$)	312		5.085%
28.252	5-alpha-Pregnan-20-one 12beta-hydroxy-($C_{21}H_{34}O_2$)	318		16.905%

RT: Retention time (sec) and MW: Molecular weight (g/moL)

to 3.2 mL by 60 min, indicating low to moderate emulsion instability. Both distilled water and synthetic emulsifiers maintained complete emulsion stability, showing no water separation throughout the 60 min.

Table 6 presents the volume of water (in mL) separated over 60 min after applying 2 mL of different emulsifiers. The blank sample again showed the highest water separation, rising from 3.8 mL at 10 min to a maximum of 5.9 mL at 50 min, indicating complete emulsion breakdown. Distilled water showed a rapid and early separation starting from 2.0 mL at 10 min, peaking at 4.8 mL by 40 min, and then stabilizing, suggesting poor emulsifying capacity. In contrast, the hexane emulsifier showed gradual water separation, increasing from 0.1 mL at 10 min to 3.0 mL at 50 min, indicating moderate emulsion instability. Both ethanol and synthetic emulsifiers showed no water separation throughout the 60 min, demonstrating excellent emulsion stability when applied at 2 mL dosage.

Table 3: Major chemical constituents identified through GC-MS analysis of the distilled water extract

RT	Compound name	MW	Structure	Composition (%)
8.917	Pentadecane, 2,6,10,14-tetramethyl ($C_{19}H_{40}$)	268		5.589
10.319	9-Decen-1-ol ($C_{10}H_{20}O$)	156		4.213
10.760	1-Octadecyne ($C_{18}H_{34}$)	250		3.266
11.847	Hexadecanoic acid, ethyl ester ($C_{18}H_{34}O_2$)	282		15.208
13.432	(E)-9-Octadecenoic acid ethyl ester ($C_{20}H_{38}O_2$)	310		28.572
13.489	trans-9-Octadecenoic acid, pentyl ester ($C_{23}H_{44}O_2$)	352		21.275
13.650	Octadecanoic acid, ethyl ester ($C_{20}H_{40}O_2$)	312		11.307
18.965	Decanoic acid, 2-propenyl ester ($C_{13}H_{24}O_2$)	212		3.009
20.258	Palmitic acid vinyl ester ($C_{18}H_{34}O_2$)	282		4.575
22.885	(2Z,4E)-3,7,11-Trimethyl-2,4,10-do decatriene ($C_{15}H_{26}$)	206		2.985

RT: Retention time (sec) and MW: Molecular weight (g/moL)

Table 4: Summary of the phytochemical components of the different extracts

Phytochemical	Hexane extract	Ethanol extract	Distilled water extract
Tannins	+	+	-
Saponins	-	++	+
Terpenoids	+	-	-
Flavonoids	-	++	-
Alkaloids	-	++	+
Cardiac Glycosides	-	-	-
Anthraquinones	-	+	-

++: Absolutely present, +: Moderately present, -: Below detectable limit

Table 5: Volume of water separated with 1 mL of emulsifiers at different time intervals

Emulsifier	10 min	20 min	30 min	40 min	50 min	60 min
Hexane emulsifiers	0.8	0.2	0.2	1.2	2.8	3.2
Ethanol emulsifiers	0	0	0	4.5	5.5	5.5
Distilled water emulsifiers	0	0	0	0	0	0
Synthetic emulsifier	0	0	0	0	0	0
Blank	3.8	4.5	5.5	5.8	5.9	5.9

DISCUSSION

The results obtained from the study, as shown in Tables 1-3, show that the Hexane, Ethanol, and aqueous extracts of the leaves of *Jatropha tanjorensis* contain biologically active compounds at various concentrations. The Ethanol extract showed a greater percentage of saponin compared to distilled water and n-hexane extracts. The distilled water and ethanol extracts emulsified the water in oil, but better results were obtained with the distilled water extract. Synthetic emulsifiers were seen to be higher in concentration, hence their efficiency in emulsifying solutions. The phytochemical analysis of the different extracts reveals that *Jatropha tanjorensis* leaves contain different bioactive compounds. Earlier researchers have made similar reports that plant materials are composed of different phytochemicals[13].

Table 6: Volume of water separated with 2 mL of emulsifiers at different time intervals

Emulsifier	10 min	20 min	30 min	40 min	50 min	60 min
Hexane	0.1	0.6	1.4	2.4	3.0	3.0
Ethanol	0	0	0	0	0	0
Distilled water	2.0	4.6	4.7	4.8	4.8	4.8
Synthetic emulsifier	0	0	0	0	0	0
Blank	3.8	4.5	5.5	5.8	5.9	5.9

The compounds include: Alkaloids, Flavonoids, Saponins, Tannins, etc. These were more in the ethanol extract than in the hexane and distilled water extracts, indicating that the nature of solvents determines the type of components extracted.

The emulsification results presented in Tables 5 and 6 show that with 1 mL volume concentration of each of the extracts, only distilled water was able to emulsify completely. This may be because the extract has a sufficient amount of saponin, which was able to reduce the surface tension between the liquids and increase the emulsification ability. Ethanol extract emulsified partially, while n-hexane extract formed a very clear separation at the surface, implying that the extract was not able to break the interfacial tension between the two liquids. This is in line with the reports from earlier studies[14-16].

With a 2 mL concentration of the extracts, the ethanol solvent extract emulsified completely, whereas the n-hexane and distilled water extracts were unable to emulsify. The inability of the extracts to emulsify may be as a result of the insufficient amount of surfactant compounds in the extracts (that is, saponin-rich components), so they were unable to reduce the surface tension between the water and oil surfaces. Earlier researchers[13] made similar observations and reported that the ability of an extract to emulsify completely is affected by the concentration of the extract. Also, the demulsification recorded with the n-hexane extract at all concentrations is attributed to the polar phytochemical compounds present in the extract. Similar observations have been made[13,16].

This study was limited in evaluating the solvent that exhibited the maximum percentage of the surface-active compound with optimal emulsification potency.

Further research should be carried out with other solvents and at extended contact time, to determine the solvent that extracts the maximum percentage of the surface-active compounds that will give the optimal emulsification

CONCLUSION

Jatropha tanjorensis leaf extracts contain various bioactive compounds with surfactant properties that influence their emulsifying or demulsifying behavior. The ethanol and distilled water extracts effectively emulsified oil in water mixtures, with the ethanol extract showing superior performance due to higher saponin content. In contrast, the n-hexane extract exhibited demulsifying activity. Emulsification improved with higher extract concentrations, supporting the potential of these natural extracts as alternatives to synthetic emulsifiers.

SIGNIFICANCE STATEMENT

This study revealed that the leaves of *Jatropha tanjorensis* contain a good number of bioactive compounds, which are surface-active agents. With this, the extracts from the leaves of *Jatropha tanjorensis* can be used to emulsify oil in a water solution. The results from this study will encourage industries to replace the existing synthetic emulsifiers, which are not eco-friendly, with this extract. Thus, a new green emulsifier has been discovered.

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