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Comparative Study on the Cosmeceutical Properties of Oils from *Dacryodes edulis* (African Pear) and *Persea americana* (Avocado) Fruits

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Abstract Fruits are major sources of oils for human nutrition as well as for several industrial purposes. The properties of *Dacryodes edulis* fruit oils from two locations (Uyo and Ikom) were compared to those of *Persea americana*, a widely used oil in cosmeceutical formulations. All the oils extracted from each of these fruits were liquid at room temperature. The oil yield of *P. americ*ana (18.55%) was low in comparison to those of *D. edulis*-Uyo (49.57%) and *D. edulis*-Ikom (52.49%). The saponification value of *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils were 189.33 mgKOH/g, 188.64 mgKOH/g and 185.13 mgKOH/g respectively, indicating their potential application in soap making. Fourier Transform Infrared (FT-IR) spectra of *P. americana* and *D. edulis* oils appear very similar, however, they revealed slight differences. Soap produced with *D. edulis* oil from Uyo gave the best quality soap considering the high fatty matter of 89.2% as compared to that of *D. edulis* soap from Ikom oil (65.4%) and soap from *P. americana* oil (70.8%). The oils from these fruits could be used as emollients in cosmeceuticals. The higher oil yield of the fruits of *D. edulis* than *P. americana*, with similar functional groups (C-HCH_3, C=O, C-O, C-HCH_2 and -CH=CH), could project *D. edulis* oils as possible substitute for *P. americana* oil in cosmeceutical formulations.

Keywords *Dacryodes edulis*, *P. americana*, Oils, Cosmeceutical formulations

1. Introduction

Vegetable oils have been used on skin for cosmetic and medical purposes. They act as protective barriers to the skin by occlusive effect, allowing the skin to retain moisture, thereby, resulting in hydration of the skin [1]. *Dacryodes edulis* (African pear) is an indigenous fruit tree in the humid low lands and plateau regions of West, Central African and Gulf of Guinea countries [2]. The fruits of *D. edulis* can be eaten either raw, cooked in salt water, roasted in hot ash or grilled in the oven [3]. *D. edulis* fruit could serve the dual purpose of being a source of minerals and vitamins to human nutrition and as a raw material for industries, if properly harnessed. The pulp and seed of *D. edulis* had been found to contain reasonable amounts of oil [4, 5]. [4] Reported the percentage oil content in D. e. var. edulis and D. e. var. parvicarpa to be 68.29% and 54.68% and [5] reported 32.56% oil content for unspecified variety of *D. edulis*. [2] Reported 32.62 - 35.05% oil content of *D. edulis* at different stages of fruit development. [6] Reported the fatty composition of *D. edulis* oil to be rich in saturated fatty acids, having palmitic acid (44.31%) and stearic acid (8.07%), and unsaturated fatty acids having oleic acid (42.45%) and linoleic acid (5.17%). *D. edulis* oil from ripe fruits had been used as a precursor for synthesis of surface coating driers [6].

Persea americana (avocado) is a medium sized tree, measuring about 9-20 meters in height. It is widely grown worldwide for fruits on large scale in various subtropical countries and are generally recognized as a popular and healthy food source supplying proteins and lipids to the human diet [7]. The fruit is not sweet but fatty, almost distinctly, yet subtly flavoured, and of smooth, almost creamy texture [8]. *P. americana* is a good source of oil, containing monounsaturated fat. Its oil content varies depending on its varieties and the period of extraction of the oil by cold-press processs [9]. [9] Reported the oil content of 27.12%, pH of 5.7; iodine value of 37.26 g/100g and saponification value of 219.20 mgKOH/g from the fruit pulp.

The binding of water in the stratum corneum can become compromised and ineffective. In this case it is helpful to reduce the transepidermal water loss by applying occlusive films. Mineral oil should be used; however, the benefits of a natural vegetable oil is preferred [10]. Natural oils are of

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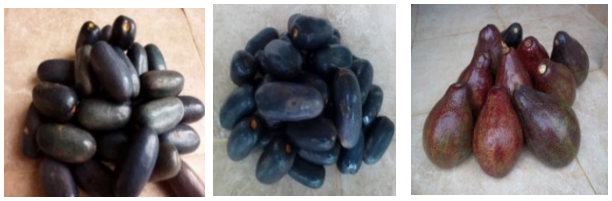
significant nutritional importance and are also desirable emollients for skin care applications. Natural oils are good sources for tocopherols and phytosterols, components offering both antioxidant activity and bioactivity for skin care applications [11]. *D. edulis* and *P. americana* oils could be of great importance in cosmeceuticals intended for daily care of the face and body. Deficiency in oil could result in excessive dryness of the skin. *D. edulis* and *P. americana* oils could serve as a cosmetic base which would prevent water loss through the skin, mainly by means of making a protective layer on the epidermis. They could also soften the skin, thereby reducing fine wrinkles.

This is the first comparative study to project *D. edulis* oils as possible substitute for *P. americana* oil in cosmeceutical formulations.

2. Materials and Methods

2.1. Sample Collection and Identification

D. edulis fruit was collected from Uyo (A) in Akwa Ibom State and Ikom (B) in Cross River State, Nigeria. Also *P. americana* fruit (C) was collected from Oron in Akwa Ibom State, Nigeria. The samples were transferred into polyethelene bags, labelled properly and taken to the laboratory for identification and preparation. The fruits were identified and authenticated by a Taxonomist in the Department of Botany and Ecological Studies, University of Uyo, Akwa Ibom State, Nigeria. Voucher specimens were deposited at the herbarium with the number, UUH 3541 and 3546 for *D. edulis* and *P. americana* respectively.



A B C

Figure 1. Experimental samples: *D. edulis* fruits from Uyo (A), *D. edulis* fruits from Ikom (B) and *P. americana* fruits (C)

2.2. Oil Extraction

Ripe fruits of *D. edulis* from Uyo and Ikom were washed with water, put in polyethylene bags for 24 hours for the fruit to soften. The pulps were removed and mashed using mortar and pestle to have a smooth paste. Also, unripe fruits of *P. americana* were kept for about 48 hours at room temperature until they were ripened. The fruits were cut open with a stainless-steel knife to remove the seed from the pulp, and the skin was removed from the pulp. The pulps were mashed using mortar and pestle to have a smooth paste. Each of the mashed samples were spread on stainless-steel trays and dried in the sun for 6 hours. The samples were scraped from the trays into clean white cotton cloths, wrapped and squeezed.

The yield of the oil was calculated using Equation (1), expressed as percentage of the dry weight of the sample [12]. The oils collected were stored in airtight bottles in a functional refrigerator for further use.

$$\text{Yield (\%)} = A1/A2 \times 100 \quad (1)$$

Where A1 = weight of extracted oil (g)
A2 = weight of dry sample (g)

2.3. Characterisation of the Oils

The cold pressed oils of *D. edulis* fruits (from Uyo and Ikom) and *P. americana* fruits were analysed without further purifications for their physicochemical properties viz: freezing point, melting point, pH, smoke point, moisture content, acid value, iodine value and saponification value using standard methods. All the determinations were done in duplicates.

2.3.1. Determination of Moisture Content

The method described by [13] was used to determine the moisture content of the oils. A well labelled crucible was dried in an oven at 105°C. The crucible was allowed to cool in a dessicator and weighed to a constant weight. Each of the oils (2 g) was added to the crucible, the weight of the crucible with the oil was taken and dried in an oven at 105°C. The crucible with the oil after drying was cooled in a dessicator and weighed to a constant weight. Percentage moisture content was calculated using Equation (2).

$$\text{\% moisture content} = \frac{b-c}{b-a} \times 100 \quad (2)$$

Where
a = weight of empty crucible (g)
b = weight of crucible + oil before drying (g)
c = weight of crucible + oil after drying (g)

2.3.2. Determination of Freezing Point

The oil (10 cm^3) in a test tube was inserted in a cup containing ice blocks, the temperature at which the oil began to freeze was recorded using a thermometer [14].

2.3.3. Determination of Melting Point

The melting point of the oil was determined by the method described by [13]. The oil (10 cm^3) in a test tube was inserted in a cup containing ice blocks and left to solidify. The solidified oil in the test tube was removed from the ice block, the temperature at which the oil began to melt was recorded using a thermometer.

2.3.4. Determination of Smoke Point

The oil (10 cm^3) was measured into a clean dried crucible and heated on a hot plate. The temperature at which the oil started to form a bluish smoke was recorded using a thermometer [15].

2.3.5. Determination of pH of oil

The oil (50 cm^3) was measured into a clean dried beaker and the probe of a digital pocket-sized pH meter was introduced into the oil and pH recorded at room temperature [16].

2.3.6. Determination of Acid Value (AV)

The acid value of the oils was determined by using ASTM D465-05 standard method [17]. The individual oils (1 g) was measured into separate conical flasks, followed by addition of 25 cm^3 of carbon tetrachloride (CCl_4). Two (2) drops of phenolphthalein indicator were also added to the mixture. The mixture was titrated with 0.1 M alcoholic potassium hydroxide (KOH) solution until a colour change was obtained. A blank titration was also carried out without the oil. The acid values of the oils were computed using Equation (3).

$$\text{Acid value (AV)} = \frac{V \times M}{W} \times 56.1 \quad (3)$$

Where
M = concentration of standard KOH solution ($moldm^{-3}$)
V = volume of KOH used for sample (cm^3)
W = Weight of the individual oils (g)
56.1 = Molar mass of KOH

2.3.7. Determination of Saponification Value (SV)

The ASTM D464-05 standard method [17] was used to determine saponification value. Two grams (2g) of the individual oils were weighed separately in a conical flask and 25 cm^3 of 0.5 M ethanolic potassium hydroxide solution was added. Each flask was heated in a steam bath, refluxing for 30 minutes with occasional swirling. The resultant solutions were then titrated with 0.5 M hydrochloric acid (HCl) using 2 drops of phenolphthalein indicator until the pink colour just disappeared. A blank determination, that is, without the oil, was carried out under similar conditions. The saponification values were calculated using the Equation 4.

$$\text{Saponification value (SV)} = 56.1 \times \frac{M\ (B - A)}{C} \quad (4)$$

Where
M = Concentration of standard HCl ($moldm^{-3}$)
C = weight of the individual oils (g)
B = volume of HCl used in the blank titration (cm^3)
A = volume of HCl used in the test titration (cm^3)

2.3.8. Determination of Iodine Value (IV)

The ASTM D5768-02 standard method [17] was used to determine the iodine value of the individual oils. To 0.5 g of the individual oils in a separate conical flask, 20 cm^3 of carbon tetrachloride was added to the oil. The resultant solution was mixed with 25 cm^3 Wijs solution. Each flask with its content were stoppered, swirled to mix, and allowed to stand in the dark for 1 hour at room temperature. Then 20 cm^3 of 10% aqueous potassium iodide and 100 cm^3 of water were added to the contents in each of the flasks. The content of the flask was titrated with 0.1 M sodium thiosulphate solution until the yellow colour almost disappeared. Starch indicator (1 cm^3 of 1%) was added and the titration continued by adding more sodium thiosulphate solution until the blue-black colouration disappeared after vigorous shaking. A blank determination was carried out in the same manner under similar conditions. The iodine value for the oils were determined using (5).

$$\text{Iodine value (IV)} = 12.69 \times \frac{M\ (B - V)}{S} \quad (5)$$

Where
M = concentration of standard $Na_2S_2O_4$ ($moldm^{-3}$)
S = Weight of individual oils (g)
V = Volume of $Na_2S_2O_4$ used in test titration (cm^3)
B = Volume of $Na_2S_2O_4$ used in blank titration (cm^3)

2.3.9. Infrared Spectroscopy (IR)

Fourier Transform Infrared (FTIR) spectra of the individual oils were obtained using IR Affinity-1S Fourier Transform Infrared spectrophotometer. A horizontal attenuated total reflectance (ATR) sampling accessory equipped with zinc selenide (ZnSe) cell was employed. The cold-pressed oils were used without further purification. Approximately 20 mg of the individual oils were placed in the sampling accessory obtaining the best contact with the crystal. The approximate total time required for spectral collection was 5 min. All spectra were recorded within a range of 4000-650 cm^{-1} with a 4 cm^{-1} resolution. Analyses were performed in dry atmosphere (18 ± 0.5°C). Each spectrum was calculated as the average of 20 scans and subjected to background subtraction.

2.4. Soap Production and Analysis

The method of [18] was used for soap production. The individual oils (100 g) of *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* respectively were weighed into separate 500 cm^3 beakers, heated to about 100°C and saponification was initiated by adding 20 cm^3 of 23.5% sodium hydroxide (NaOH) solution. To the resulting solution, 60 g of NaOH pellets dissolved in 100 cm^3 of deionised water was added gradually while stirring until completion of saponification. NaCl (8 g) dissolved in 30 cm^3 of deionised water was added to grain soap. The salt was added to separate the spent lye in the bottom, while saponified mass floats on the surface to reduce the soap viscosity and to separate the glycerol water in the bottom. The glycerol water was removed by siphoning. The soap paste was washed with 10 $cm^3$of hot water (90°C) to reduce excess sodium hydroxide and sodium chloride and any impurities found in the soap paste. The soap obtained was washed again with 10 cm^3 of distilled water, filtered using a linen cloth, then a small amount of water was added to soften it whilst heating. The soap was placed in a mould and allowed to dry.

2.4.1. Determination of Total Fatty Matter (TFM)

Total fatty matter of individual soap produced was determined using the method of [18]. Each soap (10 g) was weighed in a beaker and 150 cm^3 of deionised water, 20 cm^3 of 15% tetraoxosulphate (VI) acid (H_2SO_4) solution were added. The mixture was heated until the soap dissolved to form a clear solution. Fatty acid on the surface of the resulting solution was solidified by adding 7 g of candle wax and reheated. The solution was allowed to cool to form a cake on the surface of the solution. The cake was removed and left at room temperature to dry to a constant weight. The cake was weighed to obtain the total fatty matter using the Equation (6).

$$\% \text{ TFM} = \frac{A - B}{W} \times 100 \quad (6)$$

Where A = weight of wax + oil (g)
B = weight of wax (g)
W = weight of soap (g)

2.4.2. Determination of Free Caustic Alkali

Free caustic alkali was determined using the method of [18]. Produced soap (5 g) was weighed into a conical flask and 30 cm^3 of ethanol was added and the mixture heated until a clear solution was obtained. Barium chloride (10 cm^3 of 20%) was added and the solution turned cloudy milky, which later turned pink with addition of few drops of phenolphthalein indicator. The resulting solution was titrated against 0.05 M H_2SO_4 solution. Free caustic alkali was calculated using Equation (7).

$$\text{NaOH} = \frac{0.31 \times V_A}{W} \quad (7)$$

Where V_A = volume of acid used (cm^3)
W = weight of soap (cm^3)

2.4.3. Determination of Moisture Content

A crucible was dried in an oven at 105°C to a constant weight. The crucible was removed and cooled in a desiccator. The produced soap (3 g) was accurately weighed using analytical balance into the dried crucible and dried in an oven at 105°C and cooled in a desiccator to a constant weight [18]. The % moisture content was calculated using Equation (8)

$$\% \text{ Moisture} = \frac{Cs - Ch}{Cs - Cw} \times 100 \quad (8)$$

Where
Cw = weight of crucible (g)
Cs = weight of crucible + sample before heating (g)
Ch = weight of crucible + sample after heating (g)

2.4.4. Determination of pH of Soap

The soap (2.0 g) was weighed into a clean beaker, 20 cm^3 of water was added to dissolve the soap in order to prepare 10% aqueous solution of soap. The pH of 10% aqueous solution of the soap was measured by using a pocket-sized digital pH meter at room temperature [19].

3. Results and Discussion

The physicochemical properties of oil from *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* fruits namely: yield, freezing point, melting point, pH, smoke point, moisture content, acid value, iodine value and saponification value are shown in Table 1.

Table 1. Characterization of Oil from *D. edulis*-Uyo [D. e (U)], *D. edulis*-Ikom [D. e (I)] and *P. americana* [P. A] Fruits

Test	Sample		
	D. e (U)	D. e (I)	P. A
Yield (%)	49.57	52.49	18.55
Saponification value (mgKOH/g)	189.33	188.64	185.13
Acid value (mgKOH/g)	5.610	5.049	3.927
Iodine value (gI_2/100g)	51.78	50.25	65.99
pH	5.7	6.2	4.9
Smoke point (°C)	210	212	216
Freezing point (°C)	22	18	15
Melting point (°C)	23	19	16
Moisture content (%)	1.22	1.14	1.24

The oil yield of *P. americ*ana was low in comparison to those of *D. edulis*. This low yield of the *P. americ*ana oil than *D. edulis* can be attributed to high moisture content in the pulp or due to genetic factors of the plants. The high oil yield for *D. edulis* implies that, processing of *D. edulis* oil for the personal care Industry or edible purposes will be more economical as fruits of *D. edulis* contain more oil than fruits of *P. americana*. It had been established that oil contents of *P. americana* varies depending on its varieties and the period of extraction of oil by cold-press processs [9]. The oil yield of *D. edulis* fruits-Uyo was lower than that reported [4] in D. e. var. *edulis* and D. e. var. *parvicarpa* but higher than that reported by [2, 5]. The oil yield of *D. edulis*-Ikom was lower than that reported for D. e. var. *edulis* but close to that reported for D. e. var. *parvicarpa* [4] but was higher than that reported by [2, 5]. The oil yield of *P. americana* was lower than that reported by [9].

The pH of *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils were 5.7, 6.2 and 4.9 respectively. This reveals that the oils were weakly acidic, hence, they contain low amount of fatty acids making them fit for edible purposes [16]. High levels of free fatty acids especially linoleic acids are undesirable in finished oils because they can cause off-flavours and shorten the shelf life of oils [20]. However, linoleic acid strengthens the lipid barrier of epidermis in dry skin, protects against transepidermal loss of water and normalises the skin metabolism [21]. The pH of the oils was within the skin pH, so the oils could be applied on skin with no irritation.

Moisture contents of *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils were 1.22%, 1.17% and 1.24% respectively.

Water is an unusual component of oils and fats, as the two are non-miscible and the presence of water can be compatible only at very low proportions. However, even very low moisture contents can prove to be harmful to oils and fats products, as water is a catalyst of almost all chemical degradation reactions. Moisture content generally provides a good indication of the level of the other quality parameters of oil and can also prove very helpful to forecast subsequent variation upon storage. The presence of high moisture content enhances oxidative degradation [22]. The moisture content of these oils were low, indicating that they will maintain their quality parameters for a long time. Lower moisture content of oil implies good shelf-life.

The melting and freezing points of *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils were 23°C, 19°C, 16°C and 22°C, 18°C, 15°C respectively. *P. americana* oil had the lowest melting and freezing points followed by *D. edulis*-Ikom oil and *D. edulis*-Uyo oil had the highest melting and freezing points. The variation in melting (23°C, 19°C, 16°C) and freezing (22°C, 18°C, 15°C) points for *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils respectively could be due to differences in fatty acid composition or free fatty acids in the oil.

The smoke point of *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils were 210°C, 212°C and 216°C respectively. This reveals that *D. edulis* oils' smoke point are comparable with *P. americana* oil. Smoke point is the temperature at which oil starts to be visibly smoking in the pan of the oil. It provides a useful characterization of its suitability for frying. The smoke point of an oil increases as free fatty acid content decreases. Heating an oil produces free fatty acids and as heating time increases, more free fatty acids are produced, thereby decreasing smoke point [23]. A healthy oil becomes unhealthy when it reaches its smoke point. When an oil reaches its smoke point, the structure of the oil begins to break down, nutrients are lost, flavour is changed and most dangerously, compounds can be created that are damaging to health. This result implies that these oils could be used for frying but not above their respective smoke points so as not to create free radicals, which are damaging to health.

The saponification value of *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils were 189.33 mgKOH/g, 188.64 mgKOH/g and 185.13 mgKOH/g. The saponification value of *D. edulis*-Uyo and *D. edulis*-Ikom oils are comparable with *P. americana* oil. The saponification value of these oil can be compared to the value (188.8 mgKOH/g) obtained by [13]. Saponification value of oil serves as an important parameter in determining the suitability of oil in soap making. The high saponification values of the oils in this research is an indicative of high proportion of medium fatty acids and potential application in soap production [24]. [29] Reported low saponification values of some oils, indicating that they contain high proportion of long chain fatty acids.

The acid values obtained in *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils were 5.610 mgKOH/g, 5.049 mgKOH/g and 3.927 mgKOH/g respectively. Acid value gives an indication of the quality of fatty acids in oil. Low acid value in oil indicates that the oil will be stable over a long period of time and protect against rancidity and peroxidation. Acid value is used as an indicator for edibility of an oil and suitability for use in the paint and soap industries.

The level of unsaturation measured by iodine value is one of the most important properties of triglyceride oils that determine its industrial applications. Iodine value could be used to quantify the amount of double bonds present in the oil which reflects the susceptibility of the oil to oxidation [20]. The iodine value obtained in *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* oils were 50.25 $gI_2/100g$, 51.78 $gI_2/100g$ and 65.99 $gI_2/100g$ respectively. This indicates that *P. americana* oils may have more unsaturated bonds than *D. edulis*. The iodine value of *P. americana* was higher than the values for *D. edulis*-Uyo and *D. edulis*-Ikom but none of their values was more than 100 $gI_2/100g$. This implies that these oils could be classified as non-drying oils, and could be used as emollient to soften the skin. Non-drying oils are not suitable for ink and paint production due to their non-drying characteristics but may be useful in the manufacture of soaps and can be regarded as liquid oil [20]. Non-drying oils are slow to oxidize and so remain liquid for a long time. This quality makes them particularly useful as lubricants and as a fuel for lamps. This implies that *D. edulis* and *P. americana* oils can be used on skin to protect the skin barrier by occlusive effect, allowing the skin to retain moisture, resulting in decreased transepidermal water loss. The skin will then be moisturized, thereby making the skin to be soft and pliable, reducing fine wrinkles.

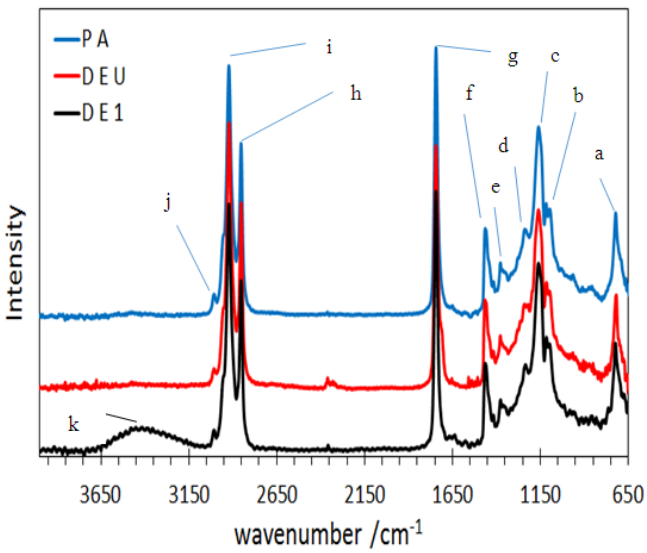


Figure 2. FTIR of *P. americana* (P A), *D. edulis*-Uyo (D E U) and *D. edulis*-Ikom (D E I)

The FT-IR analysis of D. e (U), D. e (I) and P. A oils is shown in Figure 2 and the functional groups identified in the FTIR spectra of the oils are shown in Table 2.

Table 2. Functional Groups Identified in P A, D E U and D E I Oils

Frequency (cm^{-1})	Functional group	Intensity
3450 (k)	OH stretching	Weak
3007 (j)	Cis C=CH stretching	Medium
2922 (i)	C-HCH_2 asymmetric stretching vibration	Very strong
2852 (h)	C-HCH_2 symmetric stretching vibration	Very strong
1743(g)	Carbonyl C=O from ester	Very strong
1463 (f)	C-HCH_2 scissoring bending	medium
1377 (e)	C-HCH_3 scissoring bending	Weak
1234 (d)	C-HCH_2 scissoring bending	Weak
1161 (c)	-CH in plane	medium
1114 (b)	C-O from ester	Weak
721 (a)	-CH=CH- bending out of plane	Medium

FTIR Spectroscopy is a very good method to analyse the authenticity of fat and oil because it exhibits finger print characteristics. The FTIR spectra of *P. americana* (P A), *D. edulis*-Uyo (D E U) and *D. edulis*-Ikom (D E I) oils (Figure 2) appear very similar; however, they revealed slight differences. The peak at 721 cm^{-1} was present in all the three oils, it indicates the presence of CH=CH functional groups. They are attributed to alkenes' functional groups in the oils. They can be part of fatty acids with unsaturated bond in the oils. The spectra of all oils revealed weak peaks at 1114 cm^{-1} which indicate C-O group from ester. The three oils also revealed weak peaks at 1377 and 1234 cm^{-1}, indicating C-HCH_3 and C-HCH_2 functional groups respectively. The strongest peak at 1743 cm^{-1} was present in the three oils, indicating C=O ester functional group. The peaks located at 2922 cm^{-1} and 2852 cm^{-1} indicate C-HCH_3 and C-HCH_2 functional groups stretching vibrations respectively. These peaks were present in all the oils' spectra and were very strong. These groups indicate the presence of methyl and methylene functional groups in the oils. The differences are seen in the weak broad peak at 3450 cm^{-1} indicating -OH group only on the spectrum of *D. edulis*-Ikom (D E I) oil. This -OH group may be from water, and it implies that the cold pressed *D. edulis*-Ikom (D E I) oil contained a little moisture. Also the intensity of *D. edulis*-Uyo (D E U) oil at 3007 cm^{-1} is not as sharp as that of the other oils. It could be that *D. edulis*-Uyo (D E U) oil has fewer unsaturated bonds than the other oils. These functional groups (C-HCH_3, C=O, C-O, C-HCH_2 and -CH=CH) identified in Figure 2 are typical of fats and oils. The FT-IR of *D. edulis* oils were comparable to that of *P. americana*. *P. americana* oil is highly priced in the cosmetic industry for its countless skin healing properties. This implies that *D. edulis* oils can also be used in personal care products for the treatment of dry skin, among other applications. It can even be more economical since *D. edulis* fruits contain more oil than *P. americana* fruits.

Moisture content is a parameter that is used in assessing the shelf life of a product. High moisture content in soap would lead to reaction of excess water with unsaponified fat to give free fatty acid and glycerol in a process called hydrolysis of soap on storage. From Table 3, *D. edulis*-Uyo oil soap had the lowest moisture content (10.33%), followed by *D. edulis*-Ikom oil soap (15.33 %), *P. americana* had the highest moisture content (21.33 %). The moisture content of *D. edulis*-Uyo oil soap was lower than 12.63% of neem soap [18]. This result implies that *D. edulis*-Uyo oil soap would have a longer shelf life than *D. edulis*-Ikom oil and *P. americana* oil soaps.

Table 3. Chemical Characteristics of the Prepared *D. edulis*-Uyo (D E U), *D. edulis*-Ikom (D E I) and *P. americana* (P A) Soaps

Characteristics	D E U (100 %)	D E I (100 %)	P A (100 %)
Total fatty matter (%)	89.2	65.4	70.8
Moisture content (%)	10.33	15.33	21.33
pH	10.1	10.4	10.3
Free caustic alkali (%)	0.07	0.09	0.02

From Table 3, the pH value of *D. eduli*-Ikom oil soap (10.4) was higher than the pH values of *D. edulis*-Uyo oil soap (10.1) and *P. americana* oil soap (10.3). The pH values of the three soaps compare with the value 10.4 of neem soap [18] and fall within the recommended range for bathing soap of 9-11 [18]. These values are slightly higher than 9.38 for cotton seed oil soap [25] and 9.11-9.99 for neem-shea butter soaps reported by [26]. The high values could be due to incomplete alkali hydrolysis resulting from the saponification process. It can be overcome by the addition of excess fat or oil or any other superfatting agent to reduce the harshness of the soap [25]. Alkaline substances neutralize the body's protective acid mantle that acts as a natural barrier against bacteria and viruses. Healthy skin has a pH 4 to 6 [27], while alkalinity favours detergency.

Table 3 reveals the percentage total fatty matter (TFM) of *D. edulis*-Uyo oil soap (89.2%), *D. eduli*-Ikom oil soap (65.4%) and *P. americana* oil soap (70.8%). The TFM of *D. edulis*-Uyo oil, *D. eduli*-Ikom oil and *P. americana* oil soaps were higher than 63.75% of neem soap as reported by [18]; and TFM of *D. edulis*-Uyo oil soap was higher than 71% - 84% of washing soaps obtained by [28]. Total fatty matter is an indication of soap quality. The more the fatty matter, the better the quality of the soap. The lower TFM value of *D. eduli*-Ikom oil soap could be due to the presence of unreacted sodium hydroxide in the mixture [29]. This implies that *D. edulis*-Uyo oil gave the best quality soap. Dry skin needs soap with high TFM of about 80%. This helps to re-hydrate the skin, making it smooth, and the high oil content within the soap acts as a lubricant throughout the day [18].

Free caustic alkali is the amount of alkali free to prevent soap from becoming oily. Free caustic alkali in *D. edulis*-Uyo oil, *D. eduli*-Ikom oil and *P. americana* oil soaps were 0.07, 0.09 and 0.02 respectively (Table 3). Ghana Standards require toilet soaps to have free alkali of 0.07 [18]. *D. edulis*-Uyo oil soap compares well with Ghana standards. *P. americana* oil soap was lower than the Ghana standard

while *D. eduli*-Ikom oil soap was higher than the Ghana standard. Excess free caustic alkali causes skin itching and clothes wear out. This implies that the amount of free caustic alkali in *D. edulis*-Uyo oil and *P. americana* oil soaps may not have any adverse effect on cloth or skin compared to *D. eduli*-Ikom oil soap.

4. Conclusions

Cold pressed oils extracted from *D. edulis*-Uyo, *D. edulis*-Ikom and *P. americana* fruits could be classified as non-drying oils and could be used as emollients in cosmeceuticals. The higher oil yield of the fruits of *D. edulis* than *P. americana*, with similar functional groups (C-HCH_3, C=O, C-O, C-HCH_2 and -CH=CH), could project *D. edulis* oils as possible substitute for *P. americana* oil in cosmeceutical formulations.

Comparatively, *D. edulis*-Uyo oil soap with lowest moisture content (10.33 %), lowest pH (10.1), highest Total fatty matter (89.2%) and free alkaline of 0.07, was the best quality soap produced from the three oils. This was followed by *P. americana* oil soap with *D. edulis*-Ikom oil soap having the least quality.

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