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Industrial Viability Study of the Avocado Seed Oil

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Abstract: The study explored the chemical industrial potential embedded in avocado seed oil. Oil was extracted from the seed of the avocado. The per cent yield gave 18.1%. The extracted oil was subjected to important physicochemical parameter analysis, the results of the analysis were compared with literature. The refractive index was 1.457; iodine value was 43.86g/100g, the acid value was 2.47, FFA was 0.51%, peroxide value was 26meq/kg, saponification value was 228mgKOH/g. The fatty acids present in the oil were determined, showing oleic acid (67.80%) as a dominance fatty acid present in the avocado seed oil. Also, the FT-IR spectrum of avocado seed oil revealed the presence of double bond which serves as a reactive site for industrial chemical modification of the oil. Avocado seed oil can, therefore, serve as a lubricant, plasticiser, and stabilizer in the industrial chemical processes.

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I. Introduction

The quest to annex a renewable source of raw materials and to address the ever-increasing pollution in the society necessitates research into plant materials, especially to leverage on its numerous nutritional and possibly industrial application. The avocado seed is not left out, from plant oil. Persea americana Mill, commonly known as avocado pear, is a tropical tree native to Mexico, Central America and South America but it is now grown worldwide. Avocados are also known as Alligator Pears, which is mainly due to their shape and the leathery appearance of their skin (NCBI, 2018).

The fruit that is grown on Persea Americana, which is an evergreen tree from the Lauraceae family. It is harvested early and then allowed to ripen gradually when it is sold commercially. This is why avocados are called climacteric fruits, which only ripen after harvesting, just like bananas (Adaramola *et al*., 2016).

Avocados are available in many varieties, but the most popular of all is the creamy Hass variety. Due to its various health benefits, this fruit is now grown in a number of countries. It has a very thick skin that protects it from pesticides. This is the reason you don't need to buy organic avocados; it is one of the safest crops in terms of its low exposure to pesticides (Avocado, 1986).

The edible part (fruit) is very popular in vegetarian cuisine, making a substitute for meat in sandwiches and salads, because of its high fat content and high in valuable, health-promoting fats (Lu *et al*., 2009). The fruit is not sweet but fatty, almost distinctly, yet subtly flavoured, and of smooth, almost creamy texture. Avocado fruits in many countries such as Mexico, Brazil, South Africa and India are frequently used for milkshakes and occasionally added to ice-cream. Avocado trees produce fruits in its hundredth, where it grows. Avocado leaves and root is reported to be curing of gastritis, gastroduodenal ulcer, hypercholesterolemia, hypertension, anaemia and exhaustion (Roger, 1999). Seed constitute a large percentage of any fruit known. In most cases, they usually discarded after consuming the fruit, which constitutes pollution to the environment.

Avocado seeds are considered a waste product in the pulp and oil production and this represents about 12% of the fruit weight in Hass species (Ikhuoria and Malik, 2001). Research has shown that oil from the seed of avocado has health and human nutritional benefit to humanity. Roger (1999) reported that the avocado seed oil can be used to control obesity. Soong and Barlow (2004), showed that avocado seed oil containing antioxidant and phenolic compound. Antioxidant slows down the rate ageing by neutralising the radical elements produced in the body. Nwaogu *et al*., (2008) reported that avocado seed is a good source of carbohydrate, protein, fat and some mineral elements such as calcium, phosphorus, potassium and magnesium.

The quantity of the avocado seed oil used for nutritional and health purposes are minute and are used occasionally. This does not allow the full utilisation avocado seed oil considering numerous tree plants in the country. Meanwhile, the industrial processing requires a tangible quantity of oil for its production, thereby, allows full utilisation of avocado seed oil. Therefore, there’s a need to examine the feasibility of utilising avocado seed oil for industrial purposes.

II. Materials

Avocado seed oil, NaOH, KOH HCl, sodium dihydrogen phosphate, sulphuric acid, Hydrogen peroxide, Kaolin, Butanol. Petri dishes, Beakers, Conical flasks, Measuring cylinders, hot plate, thermocouple, condenser and stirrer.

III. Methodology

Ripped avocado pear (Hass) fruits were obtained at the Fruit Market, Yola in Adamawa State, Nigeria. The seeds were removed, washed to remove dirt, and bad ones were screen out. The seeds were sundried; pulverized, and sieved in order to have uniform sizes.

A. Extraction of Avocado Seed Oil

Avocado seed oil was extracted manually, according to the method described by Evwierhoma and Ekop, (2016).

B. Percentage of Oil yield

Percentage of oil yield was carried out using the method described by Sadiq (2016). The weight of the oil yield is compared to the weight of the sample and calculation is done using the equation below

$$\text{Percentage of Oil Yield} = \frac{\text{Weight of oil}}{\text{Weight of sample on a dry matter basis}} \times 100$$

C. Determination of Refractive Index

The refractive index of the sample was determined using Abbe refractometer (Gidigbi *et al*., 2019). The mean value of the triplicate analysis was recorded.

D. Determination of Relative Density of the oil

The relative density of the oil was also determined using the method described by Ibrahim & Yusuf (2015). A specific density bottle was washed, dried and weighed (W1). It was filled with distilled water and weighed (W2). The water was poured off and the bottle was dried to its previous constant weight and then filled with the oil sample and weighed (W3).

$$\text{Relative density} = \frac{W_3 - W_1}{W_2 - W_1}$$

E. Determination of Acid value (%)

The acid value of the oil was determined using the method described by AOAC (2000). Ethanol was boiled on a water bath for a few minutes to remove dissolved gases. The boiled ethanol was neutralized by adding a few drops of phenolphthalein and about 10 ml 0.1N potassium hydroxide until a pale pink colour was obtained. 6 g of oil was weighed into a 250 mL conical flask and 50 ml of hot previously neutralized ethanol was added. The mixture was then brought to a boil on a water bath and the hot mixture was titrated with 0.1N potassium hydroxide solution until the pink colour (stable for few minutes) returned. The acid value was calculated from the relation shown

$$\text{Acid value} = \frac{56.1 \times V \times N}{W}$$

Where,
V= Volume in ml of standard Potassium hydroxide
N= Normality of the Potassium hydroxide solution
W= Weight in g of the sample

F. Determination of Free fatty acid (%)

The percentage of free fatty acid (as oleic acid) was obtained according to ISO (1996). Free fatty acid is calculated as oleic acid via this equation.
Thus,

$$\text{Percentage FFA (as oleic acid)} = \frac{28.2 \times V \times N \times 100}{W}$$

G. Determination of Saponification value

The method described by Pearson (1991) was employed. 2.0g of the oil sample was weighed into 200ml conical flask and 25ml of 0.5M of ethanolic potassium hydroxide solution was added. The flask was configured to a condensing set-up and heated on a water-bath for 1 hour with frequent shaking and the content was allowed to cool. The solution was then titrated with warm O.5M Hydrochloric acid using 1% Phenolphthalein indicator. Equivalent titration was performed for the blank and generated values were employed for computation according to the following relation;

Saponification value =

$$\frac{A - B \times 28.05}{Q}$$

Where
A = Volume of 0.5M of Hydrochloric acid used in the blank titration.
B = Volume of 0.5M of Hydrochloric acid used in the sample titration.
Q = Weight in grams of the oil sample.
28. 05 = Conversion Factor

H. Determination of Peroxide value

The peroxide value was determined using the method described by Ibrahim and Yusuf (2015). 2.0g of the oil sample was transferred into 250cm^3 flask and 1g of powdered potassium iodide (KI) and a solvent mixture (2:1 of glacial acetic and trichloromethane) were then added. The solution was then placed on a water bath for a few minutes for complete dissolution. 20cm^3 of 50% potassium iodide were introduced and the sample titrated with 0.1M $Na_2S_2O_3$. The indicator was a regular starch solution. A blank experiment was similarly performed.

Peroxide value =

$$\frac{(R \times B) \times \text{Molarity of } Na_2S_2O_3}{W}$$

Where, R and B stand for oil and blank samples in term of titre values, respectively.

I. Determination of Iodine value

The method described by (Ibrahim and Yusuf , 2015) was adopted in the determination of Iodine value. Wij's solution was prepared; 8.0g of iodine monochloride was dissolved in 200cm^3 glacial acetic acid. 9.0g of Iodine crystals was dissolved in 300cm^3 of carbon tetrachloride (CCl4) the two solutions were then mixed and made up to the mark with glacial acetic acid.

10g of Oil sample was weighed into a dry 250cm^3 conical flask and 10cm^3 of carbon tetrachloride was added followed by 20cm^3 of the prepared Wij's solution. The flask was stopped and kept in the dark cupboard for 30 minutes at room temperature; 15ml of 10% of potassium iodide solution and 100cm^3 of distilled water was added. This was titrated against 0.2ml Sodium thiosulfate solution using starch as an indicator. A blank titration was also conducted under the same conditions without the sample.

Iodine value =

$$\frac{(A - B) \times (N \text{ of } Na_2S_2O_3.5H_2O)}{Q} \times 12.69$$

Where;

A = volume of 0.1 in $Na_2S_2O_3.5H_2O$ solution used for the black titration.
B = Volume of 0.lm of $Na_2S_2O_3.5H_2O$ solution used for the Sample titration.
Q= Weight in a gram of the oil sample
12.69 = Conversion factor.
N = Normality

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J. Determination of GC

The fatty acid composition of the avocado seed oil was determined using a method described by Ikhuoria and Maliki (2007). JCL 6000 for windows 2.0 Chromatography Data system. The retention times of the components were compared with the time of standards. The % fatty acid was obtained using the relationship in the equation:

$$\% \text{ Fatty acid} = \frac{\text{Retention of component} \times 100}{\text{Retention time of the sample}}$$

K. FT-IR spectra

The infra-red (IR) analysis of avocado seed oil was carried out using infra-red spectrophotometer (Thermo electron corporation. Version 2.6,0, builds 2.5225 Verona Madison. W1, 53711, USA). Within 500-4000cm^{-1} (Gidigbi *et al*., 2019).

IV. Results and Discussion

Table 1. Physicochemical properties of Avocado (Hass) seed oil

Parameters	Value
Colour	Warm Yellow
Percentage of oil yield from the seed	18.1%
Refractive Index	1.457
Relative density of the oil extracted (g/cm^3)	0.98 at 28^{0}C
Acid value of the oil (g/100g)	43.86
FFA	0.51%
Saponification value (mg KOH/g oil)	228
The iodine value of the oil (mg iodine/100g)	43.86
Peroxide value of the oil (meq/kg oil)	26

The percentage oil yield was determined to be 18.1%; this is higher compared to 9.1% value reported by Ikhuoria and Maliki (2007) and 3.63% value reported by Otaigbe *et al.*, (2016). The difference may be due to the method of extraction, and the ripening stage of the avocado used for the experiment, as reported by Arukwe *et al.*, (2012) that, the ripening stages of avocado affect the percentage yield of the oil.

Density is a physical property of matter that expresses a ratio of mass to volume (m/v) and is an important physical parameter in polymer engineering processes (Gidigbi *et al.*, 2019). The density of avocado seed oil was analysed to be 0.921g/cm3. This is very close to being 0.9032g cm-1 as reported by Orhevba and Jinadu (2011), and to 0.9006g/cm3 adopted by Martin *et al*, (1987).

Refractive index is one of the cogent factors that affect the gloss of a material. Gloss is an optical property which is based on the interaction of light with physical characteristic of the surface. It is usually the ability of a surface to reflect light into a specific direction (Montemor, 2014). The refractive index of avocado seed oil was determined to be 1.457; this fall in the acceptable range for seed oil. For instance, Sodeke, (2005) reported soybean oil for 1.47 and corn oil for 1.47.The acid value is a measure of the number of carboxylic acid groups in a chemical compound.
It is used to quantify the acidity of a substance.

The acid value of avocado seed oil was 2.74mg/KOH/g, this is very close to 2.06 mg/KOH/g acidic value reported by Pushkar *et al.,* (2001). Also, Otaigbe *et al.,* (2016) gave an acid value of avocado seed oil as 3.01 mgKOH/g. the slight differences may be due to different species and the soil acidic. This result portrayed avocado seed oil as having low levels of hydrolytics and lipolytics activities (Otaigbe *et al.,* 2016). Therefore, it can be useful in the manufacture of paints and varnishes (Williams, 1996). Free fatty acid is an important variable in considering the quality of oil because the lower the FFA, the better the quality of the oil. The free fatty acid of avocado seed oil was 0.51%. Ikhuoria and Maliki (2007) reported a value of 0.37% for Avocado pulp oil. Orhevba and Jinadu (2011) reported 0.62% for the avocado pulp oil. This value obtained shows that, avocado seed oil is edible for human consumption.

The iodine value determines the amount of unsaturation contained in fatty acids. It also determines the oxidation value of the fatty acids. It is used as a parameter in process control as well as a quality parameter in traded palm oil (Britannica, iodine value). The Iodine value for avocado seed oil was 43.86 g/100g; this is a little bit higher than 42.66g/100g of avocado pulp oil reported by Ikhuoria and Maliki (2007). Also, Otaigbe (2016) *et al.,* reported 38.35g/100g for avocado seed oil. The low iodine value implied the stability of the oil with oxidation, thus considered as non-drying oil, and therefore, can be used as a lubricants or stabilizer. The saponification value of oil denotes the amount of lye it takes to convert the oil to soap and it is an important parameter to be considered in soap production. The high saponification value of 228. mgKOH/g is in proximity with 231.6mgKOH/g valued obtained by Pushkar *et al.,* (2001). The high saponification value indicates the suitability of the oil for soap making.

The peroxide value is defined as the amount of peroxide oxygen per 1kg of fat or oil. It is determined by measuring the amount of iodine which is formed by the reaction of peroxides (formed in fat or oil) with iodide ion (Wikipedia peroxide). The peroxide value of the avocado seed oil was determined to be 26meq/kg. Otaigbe *et al.,* (2016) reported 45meq/kg for avocado seed oil. The difference in peroxide value could be due to species of the sample, and varying method of analysis.

Table 2. Major fatty acids composition present in Avocado (Hass) seed oil

Fatty Acid	(%) Composition
Palmitic	11.62
Stearic	0.12
Palmitoleic	5.91
Oleic	67.80
Linolenic	0.11
Linoleic	13.67

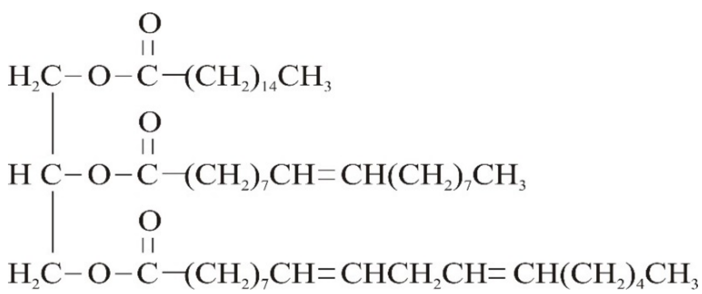

Figure 1. Triglyceride structure of avocado seed oil

The fatty acid composition of avocado seed oil showing major six fatty acids present in the oil. The monounsaturated Oleic acid ($C_{18:1}$) exhibit dominance with 67.80% of the total fatty acids. Otaigbe *et al*., (2016) reported 62.69% of the oleic fatty acid present in avocado seed oil. This shows that avocado seed oil is rich in oleic acid, which means the oil might probably be a non-drying oil, as oil rich in monounsaturated oleic fatty acid are usually stable with oxidation (Pushkar *et al*., 2001). However, oil-rich with polyunsaturated like linoleic ($C_{18:2}$) and linolenic ($C_{18:3}$) tends to be drying oil and can be used in paint binder copolymerisation. Saturated palmitic acid ($C_{16:0}$) gain dominance over the remaining saturated fatty acid present in the oil, follow by stearic acid ($C_{18:0}$).

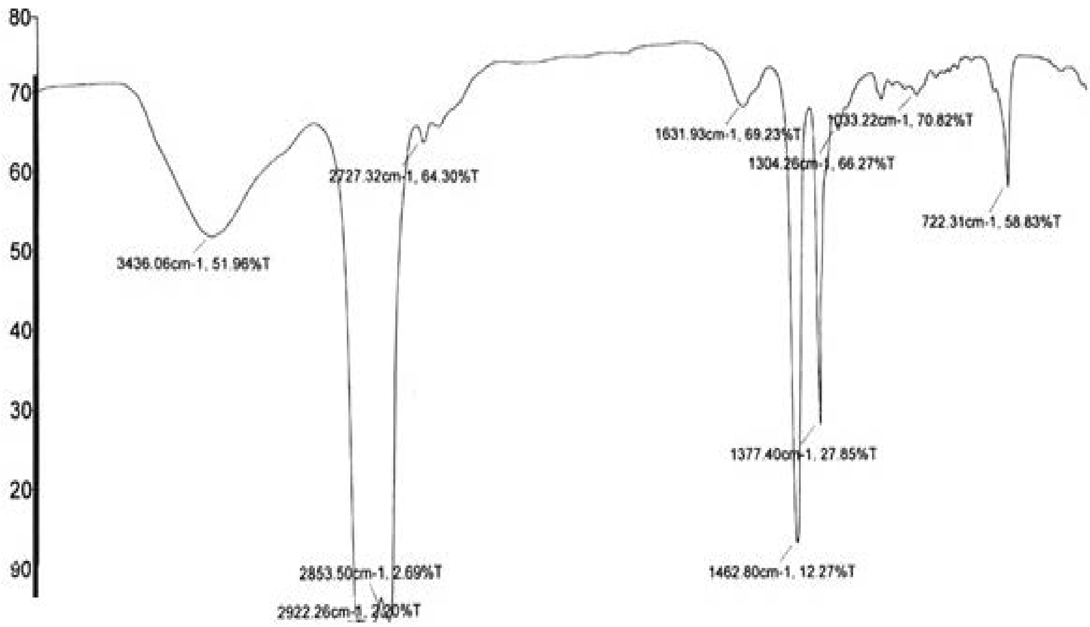

Figure 2. FT-IR spectra of avocado seed oil

FTIR spectroscopy is one of the powerful tools used in identifying and investigating the presence of functional groups in a molecule, as each specific chemical bond often has a unique energy absorption band, and can obtain structural and bond information on a complex to study the strength and the fraction of hydrogen bonding and miscibility (Kaniappan and Latha, 2011).

In the spectra of ASO, a single peak at 1631.93 cm^{-1} correspond to –C=C stretching vibration of unsaturated alkene was detected, this serve as a site for further chemical interaction (It has been proved that presence of unsaturated bond (especially –C=C-) allows the oil to be chemically modified, and can be used in the production of raw materials for industrial purposes (Wool, 2005; Tayde, *et al*., 2011). For instance, a modified oil can form polyol which is useful in the production of polyurethane in mattresses and foam production. The polyol can also be used to modify polyvinyl acetate in order to compensate for deficiency in polyvinyl acetate in water borne paint formulation (Gidigbi *et al*., 2019).

A peak at a wavelength of 1462.80 cm^{-1} shows bending vibration of $–CH_2$ alkane in the oil. The peak at 1377.40 cm^{-1} suggests the presence of $–CH_3$ bending vibration of alkane. Double peaks at 2853.50cm^{-1} and 2922.26cm^{-1} show presence of C-H stretching of alkane (Yelwa *et al*., 2017). A broadband at 3436.06 cm^{-1} shows hydroxyl stretching vibrations (Abdullahi *et al*., 2017).

V. Conclusion

The result from this analysis had shown that, apart from the nutritional benefit embedded in the oil seed of avocado, there are great potential of avocado seed oil serving as the feed stock for industrial processes. The high saponification value had shown that the oil can be used in soap making industries, while lower iodine value showed that the oil can serve as a lubricant in industrial machine, and as a stabilizer in other industrial process. The presence of double bond opened the oil to the world of industrial chemical modification , as double bond in the vegetable oils are usually utilised as a reactive sites in coatings, and can also be chemically activated by epoxidation and similar reactions in production of polyol which has numerous functions in biopolymer application. Without mincing words, Avocado seed oil has numerous industrial potential, which is waiting to be tapped.

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