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Physico-Chemical and Proximate Analysis of Vegetable Oil from Peter Mango Seed

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Abstract: Vegetable oil was solvently extracted from *Mangifera indica* (Peter mango) seeds using n-hexane as the solvent. After stripping off the solvent by rotatory evaporation the oil was dried at 55 ˚C and characterized. The result of the physico-chemical analysis showed percentage yield (% by wt), specific gravity (g/cm^3), Saponification value (mg/g) Acid value (mgKOH/g), Iodine value (g/100g), melting point (˚C) and colour be: 16.10, 1.40, 1.35, 465.63, 78.54, 8.94, 446.00, 70.00 and light yellow respectively. The results of proximate analysis determination yielded the following results for moisture content (% by vol), Total ash (% by wt), Crude fat (% by wt), Crude fibre (% by wt), Carbohydrate (% by wt) as: 1.34, 1.00, 81.20, 1.00, 1.53, 2.00 respectively. The low moisture content in the crude Peter mango seed fat is an indication that it is non-perishable and can be stored effectively. The high saponification value makes it appropriate for soap production. It's relatively high oil content shows that Peter mango seed could be a potential source of renewable energy.

1. Introduction

Lipids are heterogeneous group of substances which are present in biological materials. The term lipid is a general one that is used to describe a large group of naturally occurring fat-like substances. They are organic compounds which all contain carbon, hydrogen, and small amounts of oxygen (Preethi & Sekar, 2021). At room temperature, lipids can be oil or fat depending on the degree of unsaturation of the fatty acid components. Those with high percentage of saturated fatty acids are solids at room temperature while those with a high percentage of unsaturation are oils (Mitrea *et al.*, 2022). Whether solid or liquid, triglycerides are a major portion of a broader class of compounds called Lipids. Fats and oils are naturally occurring substances which consist predominantly of mixtures of fatty acid esters of trihydroxy alcohol or glycerol (Mitrea *et al.*, 2022; Kadda *et al.*, 2022). Different fats and oils come about due to the fact that there are numerous fatty acids of various kinds and these can be combined in an infinite number of ways on hydroxyl centers of glycerol (Amoah *et al.*, 2023). Moreover, the physical properties of fats and oils are dependent on the nature of fatty acids involved in the ester (Nandiyanto *et al.*, 2022). Hence the traditional distinction of fats and oils as liquids rises from the fact that due to the different chemical structures of the different fatty acids combined in the esters, the bonding in existence vary in strength in different melting points (Kupiec *et al.*, 2021). Other components of lipids are soluble vitamins, phospholipids, glycol lipids, fatty alcohol, terpenes, sterols and other substances (Tietel *et al.*, 2023; Liu *et al.*, 2023). Fat and oil belong to this group of compounds known as lipids which are found in living tissues e.g plant and animal tissues (Bowen-Forbes & Goldson-Barnaby, 2024). Fats and oil being substances that belong to lipids are also constructed of building block called 'triglycerides' resulting from a combination of one unit of glycerol and three units of fatty acids. In animals, oils are liberated from fatty tissues of slaughtered animals and fishes by a process called rendering. Fatty tissues occur in slaughtered animals mainly in the abdominal cavity, around the kidneys, under the skin and around muscle tissues. Domestic use of rendered fat is only of minor importance. They are mainly raw materials for the fat processing industry (Wang, 2024). In plants, they are found in seeds or fruits rich in the oils. Various techniques such as mechanical extraction, solvent extraction, and super critical fluid extraction are used to obtain oil from the seed or fruits of the plants (Daud *et al.*, 2022). Solvent extraction bridges the gap between mechanical extraction which produces oil with high turbidity metal and water content as well as super critical fluid extraction which is very expensive to build and maintain facilities (Daud *et al.*, 2022). Some kinds are suitable after extraction for table oils while others are cheap or have less popular taste and are used for obtaining products such as margarine and can also serve as oleo chemicals (Baranwal *et al.*, 2022). Oilseed crops are major crops sources of lipids for human nutrition as well as for several industrial purposes as anticorrosion… (Gaglieri *et al*., 2022; Miklaszewska *et al*., 2021; Adeleke *et al.*, 2020; Zarrok *et al*., 2014). They are defined as those crops that contain considerably large amounts of oil. The most commonly known oilseeds (conventional oil seeds) are groundnut, soyabean, rapeseed, palm kernel, cotton seed, olive, Sunflower seed, linseed, Sesame seed, safflower seed, coconut, etc (Gaglieri *et al*., 2022; Zhang *et al.*, 2023). Several unconventional vegetable oils are being explored for the potential use as domestic cooking oil and perhaps for industrial purpose. Some of these vegetable oils are from tiger nut tuber, and melon seed (Gadanya *et al.*, 2021), Pumpkin, rubber and oil bean (Karimova *et al.*, 2024). This study is a step towards the research and development of a cheaper, renewable and less known source of vegetable oil that will alleviate the problem of oil shortage and introduce another source of industrial raw material in Nigeria. Therefore, vegetable oil from Peter mango kernel one of the species of mango grown in Benue State is characterized to know the quality, purity, and yield of this oil.

2. Methodology

2.1 Sourcing and preparation of Sample

Peter mango fruits were collected from Wurukum, and Railway markets in Makurdi Local Government Area of Benue state, Nigeria. The seeds were obtained by carefully removing the peels and pulp. The seeds were then dried under the sun to prevent decay of seeds and also enhance proper loss of moisture. The dried seeds were then dehulled manually and crushed with mortar and pestle then roughly pulverized with a blender to increase the surface area. The powdered sample was then stored in silos. Cold extraction was then carried out with n-hexane as the solvent (Cravotto *et al.*, 2022). The resulting oil was heated at a temperature of 55 °C (130 °F) to dry it. The oil was then characterized. The reagents used for the oil extraction as well as the characterization were of analytical grade and were used without further purification.

2.2 Experiments

2.2.1 Proximate Analysis

Proximate analysis was carried out on the crude oil sample obtained from peter mango seed. The analysis include: Moisture content, total ash, crude fat, crude fibre, protein content and carbohydrate content. This was done according to the methods of Association of official Analytical Chemists (Hall & Mertens, 2023).

2.2.2 Physico-Chemical Analysis

The physico-chemical analysis of the crude Peter mango seed oil was carried out. The method of analysis of Association of Official Analytical Chemist (Hall & Mertens, 2023) was adopted for the determination of acid value, melting point, specific gravity. The Pearson's method as presented by (Amua *et al.,* 2023) was adopted for the determination of peroxide and saponification values. The American Society of Testing and Materials (ASTM) method as described by (Surma *et al.,* 2021) was used in the determination of Iodine value.

2.2.3 Determination of Acid value

The method of analysis of the Association of Analytical Chemist (Hall & Mertens, 2023) was used. In this method, 1 g of the sample was weighed into 250 ml conical flask and 50 ml of a mixture of (25 ml ethanol and 25 ml petroleum ether) was added. 2-3 drops of phenolphthalein indicator were added. This was titrated against 0.1 M potassium hydroxide until a pink colour which persisted for 15 seconds was obtained. The acid value was calculated by this formula:

$$A.V = V \times 56.1/W$$

A. V. = Acid value
W = weight in grams of the sample

2.2.4 Determination of peroxide value

The Pearson's method was adopted and determined as presented by (Amua *et al.,* 2023). In this method, 2 g, of the oil sample weighed and transferred into a hot boiling tube, 1 g of powdered KI was added while the contents in the boiling tube. 20 ml of the solvent mixture (2 vols glacial acetic acid and 1 vol chloroform) was added and allowed to boil for 30 minutes. The contents were quickly transferred into a flask containing 20 ml of 5 % KI. The boiling tube was washed twice with 25 ml of water and titrated with 0.002 M sodium thiosulphate solution using 1 % starch indicator. A blank was also carried out. The peroxide value was determined by this formula:

$$P.V = T \times M/g \times 10$$

P.V = Peroxide value
T = Titre value of sodium thiosulphate
M = Molarity of sodium thiosulphate solution
g = weight of oil sample

2.2.5 Determination of Iodine value

The method given by American Society for Testing and Materials (ASTM) as described by (Amua *et al.,* 2023) was used in the iodine value determination. In this method, 0.2 g of the oil sample was weighed into a 250 ml Conical flask. 20 ml of tetrachloromethane was added and the flask was swirled and the resulting mixture kept in the dark for one hour. After one hour, 20 ml of KI solution (10 %) was added followed by addition of 100 ml of water. The solution was then titrated with 0.1 M sodium thiosulphate solution. The thiosulphate solution was added slowly from the burette into the flask while swirling until the yellow colour of the resulting solution was almost discharged. 3 drops of starch indicator (1 %) were added drop-wise until a blue-black colour of the starch-iodine complex was discharged. A blank titration was also carried out. The iodine value was then calculated using the equation below:

$$I.V = (B - S) \times M \times 12.59/g$$

I.V = Iodine value
B = titre value of blank titration
S = titre value of sample titration
M = Molarity of sodium thiosulphate
g = weight of sample used
12.69 = equivalence of iodine

2.2.6 Determination of saponification value

The Pearsons' method was adopted for this analysis. In this method, 2 g of the oil sample was weighed in a conical flask and 25 ml of alcoholic KOH solution was added. A reflux condenser was attached and the flask was heated in water bath for 1 hour, 1 ml of phenolphthalein (1 %) was added. The content was titrated with 0.5 mL HCl shaking frequently. The end point was from pink to yellow which disappeared completely to colourless after a few minutes. A blank titration was also carried out. The saponification value was calculated as

$$S.P = (a - b) \times 28.05/g$$

S.P. = Saponification value
a = titre value of the sample
b = titre value of blank
g = weight of oil sample
28.05 = constant

2.2.7 Determination of Moisture content

Moisture content was determined using the gravimetric method of air-oven drying to constant weight at 105 º C The moisture content was calculated as

$$M.C = \frac{W2 - W3}{W2 - W1}$$

$M.C$ = Moisture content
W2 = weight of sample + crucible
W3 = weight of sample after drying
W1 = weight of the empty crucible

2.2.8 Determination of melting point

The melting point was determined using AOCS 3-25 method as presented by (Surma *et al.*, 2021) The temperature at which the oil began to rise in the tube in the water bath kept at 30 ºC was recorded as the melting point.

3. Results and Discussion

3.1 Results

Table 1 **Proximate Composition of Mango Seed Oil**

Properties		Results
Moisture Content	% by Vol	1.34
Total ash	% by wt	1.00
Crude fat	% by wt	81.20
Crude fibre	% by wt	1.00
Protein content	% by wt	1.53
Carbohydrate content	% by wt	2.00

Table 2 **Some Physico-Chemical Properties of Mango seed oil**

Properties		Results
Percentage Yield	% by wt	16.10
Specific Gravity	g/cm^3	1.35
Saponification value	Mg/g	465.63
Acid value	mgKOH/g	78.54
Peroxide Value	Mg/g	446.00
Iodine Value	g/100g	8.94
Melting Point	˚C	70.00
Colour		Light yellow

3.2 Discussions

3.2.1 Proximate Analysis

The proximate composition of mango seed oil, as presented in the table 1, highlights its nutritional and chemical properties. The low moisture content indicates the oil's stability and resistance to microbial growth, which is essential for storage and shelf life. A low moisture content also ensures higher energy efficiency during processing, as less water needs to be evaporated. Ash content reflects the inorganic mineral residue in the mango seed oil. The value of 1.00% indicates a moderate mineral presence, which is typical for plant-derived oils and implies potential nutritional benefits from trace minerals. The high crude fat content signifies the oil's primary constituent and highlights its efficiency as an energy-dense food source. It also indicates its utility in industrial applications, such as cosmetics and biodiesel production, given its high lipid content. Crude fiber in mango seed oil is relatively low. While this is not significant for the oil's direct use, it could contribute to the seed cake's use in animal feed after oil extraction. The protein content is minimal in the oil itself, reflecting the limited role of proteins in the oil fraction of seeds. However, this value could contribute to the nutritional analysis if considering the seed residue post-extraction. The presence of carbohydrates, although low, may indicate some soluble sugars or starches retained in the oil. These can impact the oil's taste and possible fermentation applications in bioenergy or industrial processes. The data suggests mango seed oil is a rich source of lipids with minimal impurities like moisture and ash. Its nutritional profile points to applications in food and non-food industries. For example: Food Industry, Cosmetic Industry etc. These results align with findings in studies on plant seed oils, such as that by (Akhter et al., 2024), which also emphasize the economic viability of extracting oil from seeds with high lipid content. Further comparison with common seed oils like palm or soybean oil reveals mango seed oil as a competitive resource due to its lipid profile and low impurities. This analysis underscores mango seed oil's multifunctional potential while suggesting further refinement to optimize its industrial usability.

3.2.2 Physico-chemical Analysis

The physicochemical properties of mango seed oil, as presented in the table 2, provide valuable insights into its quality, potential uses, and industrial applications. The oil yield is relatively moderate compared to other seed oils like palm kernel or soybean. While not exceptionally high, this yield supports the feasibility of oil extraction from mango seeds as a by-product of mango processing, particularly in regions with abundant mango cultivation. Studies such as those by (Akhter *et al.*, 2024) highlight similar yields for underutilized seeds, emphasizing their economic potential. The specific gravity of mango seed oil is higher than that of most edible oils (commonly around 0.9 g/cm^3), which may influence its handling and processing. A higher specific gravity suggests denser oil, which could have implications for its applications in industrial and cosmetic formulations requiring a more viscous base. The saponification value is quite high, indicating a significant number of triglycerides and fatty acids suitable for soap production. Oils with high saponification values are ideal for the manufacture of solid soaps, a fact corroborated by research on tropical seed oils by (Akhter *et al.*, 2024). The acid value is an indicator of free fatty acids (FFA) in the oil. This high value suggests that the oil is prone to rancidity and may require refining to reduce FFAs for applications in food or cosmetics. For industrial purposes, such as biodiesel production, a high acid value can affect the transesterification process unless pre-treatment is applied. The peroxide value measures oxidative rancidity. A high peroxide value suggests that mango seed oil is susceptible to oxidation, which could limit its shelf life unless antioxidants are added. Research by (Akhter *et al.*, 2024) notes the importance of peroxide values in determining oil storage stability.

The iodine value reflects the degree of unsaturation in the oil. This low value indicates a predominantly saturated fat composition, contributing to the oil's stability and high melting point. Such oils are less prone to rancidity, making them suitable for long-term storage and specific industrial applications like candle production. A melting point of 70°C is higher than most edible oils, signifying a semi-solid state at room temperature. This property makes mango seed oil suitable for use in solid fat products, such as margarine and shortening, as well as in cosmetics like balms and creams.

The light-yellow color suggests minimal impurities and the presence of natural pigments such as carotenoids. This characteristic enhances its aesthetic appeal in cosmetic formulations and edible products. These results suggest that mango seed oil has potential uses in various industries including, cosmetic, soap and detergent, biodiesel and food industries. Mango seed oil exhibits unique characteristics compared to conventional oils like palm or coconut oil, especially its high peroxide and acid values. Studies such as (Akhter *et al.*,2024) highlight similar physicochemical profiles for tropical seed oils, advocating their potential for non-conventional uses. Further refining and antioxidant treatment could broaden its applicability.

Conclusion

From the result of the extraction, proximate, physico-chemical analysis and discussion *Mangifera indica* (Peter mango) seed oil with a percentage yield of 16.10 can be classified as an oil-bearing seed plant. It is obvious from the result that the oil is a non-drying oil with an Iodine value 8.94 g/100g which is within the range of (0-100). This indicates that the Peter mango seed oil will not polymerize easily and will remain a solid at room temperature. The high saponification value (465.63 mg/g) indicates that the oil has high mean molecular weight and can give good results in the production of soaps and shampoo. With a low percentage moisture content of 1.34, the oil will not perish easily. The result also suggests that the oil contains low levels of mineral content and percentage waste owing to the low percentage crude fibre (1.00) and total ash (1.00). The total crude fat determination however, gave a high yield of 81.20 indicating high fatty content of the oil. The oil extracted from mango seed should however be handled and stored properly due to the high acid value (78.54 mgKOH/g) and peroxide value (466.00 mg/g) to avoid the oil from easily going rancid resulting to stale oil since it is highly susceptible to oxidation.

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