Extraction and Characterization of Vegetable Oils from Melon (Cucumis Melo), Pumpkin (Cucurbita Mixta) & Palm Kernel Nut (Elaeis Guineensis)

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Abstract

This study seeks to extract and characterize vegetable oils of pumpkin seed *(Cucurbita Mixta)*, Melon seed *(Cucumis Melo)*, and Palm kernel nut *(Elaeis Guineensis)*. The extraction was done using Soxhlet extractor and normal hexane as solvent. The free fatty acid composition of pumpkin seed was examined using GC/FID, giving oleic acid the most dominant. Proximate composition and physio-chemical properties of seed oils were performed according to the Association of Analytical Chemists (AOAC) procedure. The results show that the seeds have high oil contents, mean iodine value of pumpkin, melon, and palm kernel (105.3946I_2/100g, 114.1529I_2/100g, and 50GI_2/100G), and specific gravity of 0.9303, 0.9205 and 0.9101 respectively. The high saponification values (186.9879, 194.4931, and 246.2977 mgKOH/g of oil) of pumpkin, melon, and palm kernel oil confer on the oils, the properties required in soap making and cosmetic industry. Other parameters examined were peroxide value (3.79meqO_2/g, 13.3meqO_2/g, and 10.9meqO_2/g), Acid values (5.30mgO_2/g, 7.61mgO_2/g and 8.97mgO_2/g of oil), while % free fatty acid are 2.5% (as oleic), 3.90% (as oleic) and 4.5% (as Lauric) for pumpkin seed oil, melon seed oil and palm kernel oil respectively. These values recorded for pumpkin oils are indicators of their ability to resist lipolytic hydrolysis and oxidative deterioration or rancidity.

Keywords: Vegetable oils, Pumpkin Seed Oil, Melon Seed Oil, Palm Kernel Oil, Oil Extraction and Physicochemical Properties

Introduction

Vegetable oils are triglycerides extracted from plants, commonly used in cooking, food preparations, industrial applications, and as biofuels. These oils are derived from seeds, fruits, and nuts and are rich in essential fatty acids, vitamins, and antioxidants. The increasing global demand for vegetable oils, driven by their wide range of applications in food, cosmetics, pharmaceuticals, and Industry sectors, has spurred interest in identifying sustainable and underutilized sources of oil. Pumpkin seeds, melon seeds, and palm kernel nuts have highlighted their potential as visible sources of high-quality oils with various applications. The extraction and characterization of oils from these seeds are critical for understanding their potential uses and economic value in various industries.

Significance of Vegetable Oils

Vegetable oils play a vital role in human diets by providing essential fatty acids and serving as the medium for fat-soluble vitamins **Belitz *et al.* (2009)**, According to **Gunstone (2021)**, they provide essential fatty acids, fat-soluble vitamins, and serve as key ingredients in cosmetics, biofuel, and pharmaceuticals. Vegetable oils are also seen as sustainable alternatives to synthetic and animal-based oils (**Yusuf *et al*, 2020)**. Furthermore, their Industrial relevance spans cosmetic pharmaceuticals and biofuel production (**Gunstone, 2021)**. Understanding the properties and extraction methods of these oils helps in optimizing their utilization across sectors, ensuring both economic and environmental benefits.

Pumpkin Seed: Pumpkin seeds (*Cucurbita mixta)* are known for their high content of unsaturated fatty acids, particularly Linoleic and Oleic. A recent study by **Thakur *et al.* (2022)** found that pumpkin seed oil also contains significant amounts of tocopherols (vitamin C), phytosterols, and other antioxidants, making it beneficial for cardiovascular health and providing anti-inflammatory properties. Research by **Amin *et al.* (2015**) highlighted the bioactive compounds in pumpkin seed oil, including tocopherols (vitamin C). The extraction methods typically used include solvent extract and mechanical pressing, with cold pressing being preferred to preserve the oil's nutritional value and bioactive compounds **(Anwar *et al*, 2021)**.

Melon Seed: Melon seeds *(cucumis melo)* are relatively underutilized despite their potential as oil sources. According to **Ogbu *et al*. (2017)**, melon seed oil is rich in essential fatty acids, particularly Linoleic and Oleic acids make melon seed oil nutritionally valuable and suitable for cosmetic applications. Ebewele et al. (2020) further confirmed the presence of Linoleic and oleic acids in melon seed oil**.**

The oil is also rich in antioxidants such as vitamin E, enhancing its stability and making it important in the skin. Melon seed oil is nutritionally valuable and suitable for cosmetic applications. Ebewele et al. (2020) further confirmed the presence of Linoleic and oleic acids in melon seed oil care and cosmetic products (**Hossain & Islam, 2013)**. Recent advancements in extraction technology such as supercritical fluid extraction have been explored to maximize oil yield while maintaining the integrity of its bioactive components **(Kaur *et al*, 2021).**

Palm Kernel Nuts: Palm kernel nut oil is obtained from the seeds of the oil palm *(elaeis guineensis).* It is rich in saturated fatty acids, especially Lauric acid, which contributes to its high stability and suitability for use in processed foods, soaps, and cosmetics (**Boateng *et al*, 2016**). A recent review by **Boateng *et al*. (2022)** emphasizes that palm kernel oil is ideal for industrial applications due to its long shelf life and resistance to oxidation making it highly valued in tropical regions. The oxidation process for palm kernel oil is typically through mechanical pressing, although solvent extraction methods are also common in industrial applications (**Dube *et al*., 2021).**

Extraction and characterization of oils from pumpkin seeds, melon seeds, and palm kernel nuts are highly relevant in today's context of sustainable development. As highlighted by **Yusuf *et al*, (2020)**, there is an urgent need to explore underutilized resources for oil production, particularly in regions where these seeds are abundant. Additionally, the characterization of these oils will help determine their optimal use in various industries, including food, cosmetics, and biofuel production. Fats and oils have been one of the important constituents of our food since prehistoric times, and for this reason, should be undertaken as a part of the study.

Aim and Objectives: The primary aim of this study is to extract and characterize the vegetable oils from pumpkin seeds, melon seeds, and palm kernel nuts, to evaluate their physicochemical properties, fatty acid composition, and potential applications in food, cosmetics, and Industrial sectors.

Objectives

1. To extract the vegetable oils using the solvent method
2. To analyze the physicochemical properties of the extracted oils, including parameters such as Iodine value, Peroxide value, Acid value, and Saponification value which are critical for determining oil quantity and stability 3. To determine the fatty acid composition of oils extracted
4. To promote the utilization of underutilized oil seed resources (Melon and Pumpkin seed)
5. To contribute to the growing body of knowledge on sustainable vegetable oil production, highlighting the importance of renewable plant-based oils in reducing reliance on synthetic and animal-based oils.

Methodology

Materials: The materials used were obtained from Rivers Vegetable Oil Company. They include Burette, Spartler, Weighing balance, Tintometer, Conical flask, Soxhlet, Pipette, Oven, and Beaker.

Sample Preparation: The dried palm kernel nuts, melon seeds, and pumpkin seeds were obtained from the local market in Choba, Rivers State. The seeds undergo various processes in the course of their preparation for extraction.

The unit operations involved are:

● **Clearing:** The seeds have some materials and dirt which were separated by hand-picking

● **Drying:** The cleaned seeds were dried in the room, cleaned, and stored in a sealed vessel wrapped with a polyethylene bag at 4^{o}C. The seeds were further dried in the oven at 60^{o}C for 7 hrs to a constant weight to reduce the moisture content

● **Winnowing:** The separation of the shell from the nibs (cotyledon) was carried out using a tray to blow away the cover to achieve a very high yield.

● **Grinding (Size reduction):** Mortar and Pestle were used to crush the seeds into a paste (cake) to weaken or rupture the cell walls to release vegetable oil fat for extraction.

Oil Extraction: Normal hexane (300g) was poured into a round bottom flask and 10 g of the sample was placed in the thimble and inserted in the center of the extractor. The soxhlet was heated at 60oc, ***(Das et al.*, 2002).** When the solvent was boiling, the vapor rose through the vertical tube into the condenser at the top. The liquid condensate drips into the filter paper thimble in the center, which contains the solid sample to be extracted. The extract seeps through the pores of the thimble and fills the siphon tube, where it flows back down into the round bottom flask. This was allowed to continue for 30 mins. It was then removed from the tube, dried in the oven, cooled in the desiccators, and weighed again to determine the amount of oil extracted. Further extraction was carried out at 30-minute intervals until the sample weight at further extraction and the previous weight became equal. The experiment was repeated by placing 5g of the sample into the thimble again. The weight of oil extracted was determined for each 30-minute interval. At the end of extraction, the resulting mixture (miscellany) containing the oil was heated to recover solvent from the oil.

The solvent used is straight-running gasoline e.g hexane, methane dichloromethane

Analytical Methods

Specific Gravity Determination: A pycnometer bottle was washed, dried and weighed. The bottle was then filled with distilled water and the weight was taken. Finally, it was filled with the sample and the weight was also taken and recorded.

Calibration of SG at 30^{o}C

SG = Sample weight/Weight of water

Acid Value: The oil sample [10ml] was taken at 250ml. conical flask and 25ml of neutral alcohol was added to it. The contents were kept in a water bath for 10 mins and titrated against 0.1N KOH solution, using phenolphthalein as an indicator until the pink color persisted. The acid value was calculated by following AOAC International, 22nd Edition [2023] method, as given below.

Acid value = 56.1 x N x V/Weight of oil sample taken

Where

N = Normality of KOH solution

V = Volume of [ml] KOH used

56.1 = Equivalent weight of KOH

Peroxide Value Determination: The peroxide value determination was according to **AOAC International's recommended practice, 22nd Edition (2023)**. 5.0g of sample was dissolved completely in 30 ml of acetic acid-chloroform [3:2 v/v] in a 250 ml conical flask and shaken for a minute before the addition of 30 ml of distilled water. 0.5ml of starch indicator solution was added before titration with 0.1N $Na_2S_2O_3$ solution until the blue-black color completely disappeared.

Calculation

Peroxide value= [S-B] x N x 1000/Weight of sample.

Where B = Titre value of the blank solution

S = Titre value of sample solution

N = Normality of $Na_2S_2O_3$

Free Fatty Acid Determination [FFA]: This was carried out when 2g of oil was put in a 250ml conical flask. It was followed by the addition of 10 ml of neutralized ethanol. The mixture was titrated with 0.1N NaOH solution after the addition of .3 drops of phenolphthalein indicator. The titration continued until an endpoint of light pink was obtained.

CALCULATION

1) % FFA [as oleic acid] = Titre difference x N x MW x 28.2/ Weight of sample

2) % FFA [as lauric acid] = TD x N x M x 220/ Weight of sample

3) % FFA [as palmitic acid] = TD x N x MW x 256/ Weight of sample

Oil Color Determination: The completely dissolved oil sample was poured into the 51/4 cell. The cell was placed within the Lovibond tintometer immediately; to determine the color of the sample by using the color racks of yellow, red, and blue. It was corrected until an accurate color match was obtained.

Oil Melting Point Determination: This test shows the temperature at which a fat or oil starts to melt. Fats and oils are chemically similar but generally fast are solid at room temperature and oils are liquid. Each fat or oil has a different melting point which is dictated by its chemical composition.

Method: A capillary tube about 1cm was dipped into a well-melted oil or fat and a thermometer was attached to the capillary tube with an elastic band so that the bulb of the thermometer is next to the plug of the fat. A retort stand was used to clamp the tube and thermometer in a beaker of ice block, such that they didn’t touch the sides or bottom of the beaker, then heat was applied. The oil and the temperature at which it becomes clear and begins to move inside the capillary tube were observed. That is the oil melting point.

Iodine Value Analysis: The iodine value is a measure of the degree of unsaturation of fats and oils and is expressed as the grams of iodine absorbed per 100 mg of sample.

Method: To 0.2g of oil, 20 ml of Wijs solution was added. Incubation for 30 mins – 1hr was done before the addition of 15 ml of 10% KI solution. 10 ml of distilled water was also added and titrated with 0.1N $Na_2S_2O_3$.

NB: 1 ml of 0.1N $Na_2S_2O_3$ = 0.01269g = [B-S] x 0.01269

The starch indicator was added and titration continued until the solution became clear.

CALCULATION:

Iodine value = [B-S] x N x 12.69/Sample (Wt)

Saponification Value Determination: Saponification value is the amount of alkali necessary to saponify a definite quantity of the sample. It is expressed as the number of milligrams of KOH required to saponify 1g of oil.

To 0.2g of oil sample, 25 ml of alcoholic potash was added. Preparation and conduction of a blank determinate were done simultaneously with the sample and similar in all respects, except omitting the oil. The air condenser was connected and heated gently, but steadily for at least 1 hr for the sample to completely saponify. 2-3 drops of phenolphthalein indicator were added and titrated with 0.5N HCL until the pink coloration disappeared.

CALCULATION:
SAPONIFICATION VALUE = [B-S] x N x 56/Weight of oil

Where B = Titre value of blank solution

S = Titre value of the sample solution

N = Normality of HCL

W = Weight of sample

Free Fatty Acid Composition Analysis: The fatty acid compositions of the samples were determined by gas chromatography [GC]. The GC was a HPSO 29P plus system equipped with a flame ionization detector [FID] [HP Company, Wilmington, D]. Methylation of the fatty acids was carried out according to the **AOAC Official Method, 22nd Edition (2023)**. A supelco SP-2560 fused silica capillary column with 100m x 0.25mm 0.02 [m film thickness [supelco, Bellefonte, PA] was used for fatty acid analysis. The helium carrier gas flow rate was 19 cm/s. The injector temperature was maintained at 250^{o}C. A temperature program with a total run time of 45 minutes was used. The initial column temperature of 140^{o}C was maintained for 5 minutes. Then oven temperature was increased to 240^{o}C at 4^{o}C/min ramp rate and kept constant at this temperature for 15 mins. The detector conditions were as follows: temperature 260^{o}C, H_2 flow rate 40 ml/min, air flow 400ml/min, and make-up gas [He] 30ml/min. oil samples were injected by an autosampler (HP 7683, HP Company, Wilmington, DE). Pea areas were calculated and data collection was managed using an HP Chemstation [Revision. *A.09.01*. Agilent Technologies, Palo Alto, CA] The split ratio was 150:1. Fatty acid peaks were identified using a standard 36 FAME mixture [Supelco 37 Component FAME Mex, Supleco and Bellefonte, PA]

RESULTS

TABLE 1. Physical Properties of Oils

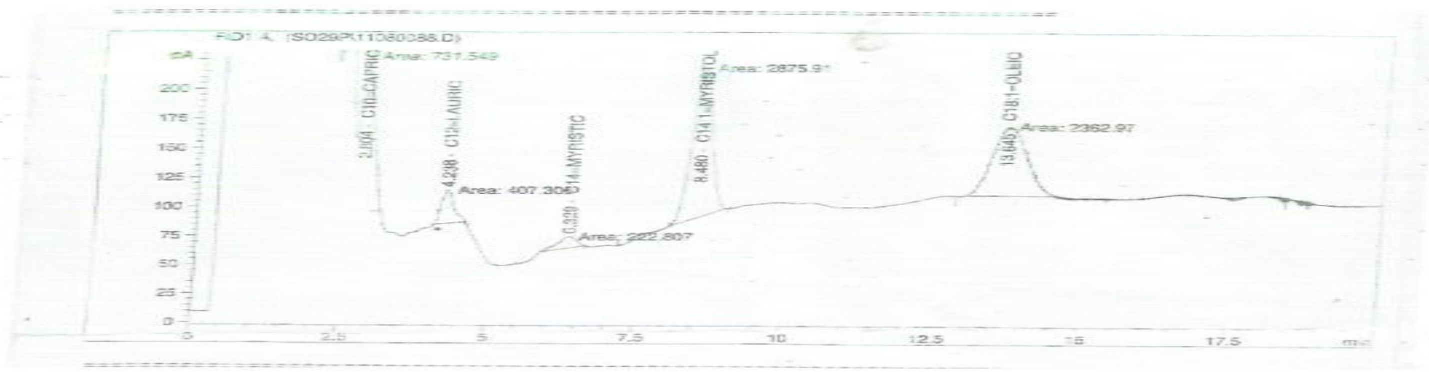
SAMPLES	Yield (%)	Specific gravity (kg/m^3)	Melting point (^{o}C)	Color	MIV (%)
Pumpkin Seed oil	**51.9**	**0.93**	**33**	**22.0 yellow, 0.8bue**	**0.39**
Melon oil	**48.3**	**0.92**	**31**	**3.4red, 18.4yellow**	**0.62**
Palm Kernel Oil	**47.7**	**0.91**	**25**	**21.4yellow, 3.4red**	**0.4628**

TABLE 2: CHEMICAL PROPERTIES OF THE OILS

Samples	FFA (%)	Acid value (mgO_2/g)	Peroxide value (mgO_2/g)	Saponification value (mgKOH/g)	iodine value ($I_2/100g$)
Pumpkin Seed Oil	2.48	5.32	3.79	186.9	105.4
Melon seed Oil	3.90	7.61	13.3	194.5	114.1
Palm Kernel Oil	4.51	8.97	10.9	246.2	50.9

TABLE 3: FATTY ACID COMPOSITION OF PUMPKIN SEED OIL

Sample (%)	Capric Acid ($C_{10:0}$)	Lauric Acid ($C_{12:0}$)	Myristic acid ($C_{14:0}$)	Myristol ($C_{14:1}$)	Oleic acid ($C_{18:1}$)
Pumpkin Seed Oil	11.08	6.17	3.38	43.57	35.79


Area: 731.549
Area: 2875.91
Area: 2362.97
Area: 407.306
Area: 222.807
C10-CAPRIC
C12-LAURIC
C14-MYRISTIC
C141-MYRISTOL
C181-OLEIC
4.238
8.480
200
175
150
125
100
75
50
25
0
2.5
5
7.5
10
12.5
15
17.5

Discussions

YIELD (%): Oil yield from pumpkin (51.9%), Melon (48.33%), and Palm Kernel (47.7%), highlights significant differences that are important for the respective applications in food, cosmetic and industrial sections. The high yield from pumpkin seeds can be attributed to the high lipid content of the seeds, making them ideal for cold pressing or solvent extraction **(Mohammed et al, 2021)**. This is consistent with findings by **Thakur *et al.* (2022), who** reported that pumpkin seeds are rich in oil and have become increasingly popular in the edible oil market. Melon seed, while slightly lower in yield, offers a good balance of oil content and health benefits. Palm kernel oil, despite having the lowest oil yield, provides a stable, long-lasting oil suitable for industrial purposes particularly in the production of soaps, cosmetics, and biodiesel (**Anwar *et al.*, 2021).** The difference in oil yield among pumpkin oil, melon seed oil, and palm kernel nut oil suggest that each has specific advantages depending on the intended application.

SPECIFIC GRAVITY: The specific gravity of the oils was found to be Pumpkin (0.93), Melon [0.92], and Palm Kernel [0.91]. The higher density of pumpkin seed oil can be attributed to its relatively high content of unsaturated fatty acids, particularly Oleic acid and Linoleic acid **Thakur *et al*, (2022)**. Oils with higher specific gravity, such as pumpkin seed oil and melon seed oil, tend to be more beneficial for health-related uses due to their positive effects on cholesterol and cardiovascular health **(Mohammed *et al.*, 2021**). On the other hand, oils with lower specific gravity, such as palm kernel oil, are more suitable for non-food applications where stability and solidification properties are required. The specific gravity values of pumpkin seed oil, melon seed oil and palm kernel oil reveal important insights into their fatty acid compositions and the potential applications of these oils.

MELTING POINT: The variation in melting points is significant for manufacturers and consumers who need to choose the right oil based on its physical behavior at different temperatures, ensuring optimal functionality in different products and environments **(Mohammed *et al.*, 2021)**. The higher melting point of pumpkin seed oil suggests a more rigid structure suitable for culinary and cosmetic uses. Melon seed intermediate melting point makes it versatile for the food and cosmetic industry, while the lower melting point of palm kernels oil emphasizes its utility in Industrial products like soap and margarine, where solid or semi-solid fats are needed.

COLOR: The difference in the color values of these oils can be linked to their varying carotenoid, chlorophyll, and other pigment content, which are influenced by the type of seed or nut, extraction methods and degree of reformation. Pumpkin seed oil with its deep yellow and slight blue tint, reflects higher unsaturated fatty acid content and the presence of chlorophyll, making it suitable for niche culinary and cosmetic applications **Tharku *et al.* (2022)**. Melon seed oil displays a more balanced yellowish-red ratio, with 3,4 red and 18.4 yellow, giving it a yellowish-orange appearance **Ojo *et al.*, (2020).** Note that the relatively lower yellow value and higher red component in melon seed oil is due to a greater presence of pigments, such as carotenoids compared to chlorophyll. Palm kernel oil has a strong yellow color (21.4 yellow) with a noticeable red component (3.4red), giving golden to light red hue. **Boateng *et al.*, (2022)** highlighted that the color of palm kernel oil is influenced by its fat content and the presence of minor compounds like tocopherols, which contribute to its oxidative stability.

% MATTER IMPURITIES AND VOLATILE MATERIALS (M.I.V): The content of M.V was 0.399%, 0.624%, and 0.463%, for pumpkin, melon, and palm kernel oil. The seed oil impurities and volatile materials are quite low. The more the volatile matter, the higher the free fatty acids it contains.

PEROXIDE VALUE: The peroxide value is a critical parameter in assessing the quality & oxidative stability of edible oils. A lower peroxide value indicates better oxidative stability **Boateng *et al.* (2021)**. The peroxide values in all the oils are high (above 10) except for pumpkin seed oil which met the acceptable peroxide value limit of 10meq0_2/Kg) of oil set by the **Codex Alimentarius Commission, (2021).** The low peroxide value of pumpkin oil is indicative of low levels of oxidative rancidity of the oil and also suggests the presence or high level of naturally occurring antioxidants such as **Tocopherol (vitamin E). Mohammed *et al.* (2021)** found that these antioxidants help protect the oil from oxidative degradation, ensuring its suitability for both culinary and cosmetic uses. The oil from melon seed and palm kernel nuts will be easily susceptible to deterioration or oxidative rancidity due to the high peroxide value. **Ebewele *et al*. (2020)** explained that the oil's higher degree of unsaturation makes it more prone to oxidation, which requires careful packaging and storage in airtight containers to preserve its quality. Certain antioxidants may be used to reduce rancidity in these oils such as propyl gallate.

ACID VALUE: The acid value represents free fatty acid content due to enzymatic activity and is usually indicative of spoilage. Its maximum acceptable level is 4mgKOH/g of oil **(CODEX Commission. (2021).** The acid values obtained from the oils under study (5.32), (7.61), and (8.97) for pumpkin oil, melon oil, and palm kernel oil respectively, are slightly above the recommended international acceptable standard for edible oils. This acid value can be made fit by subjecting the oil to refining and this may also improve its quality for industrial purposes (**Oderinde *et al.*, 2009**). Moreover, higher acid value can be linked to the presence of unsaturated fatty acids which are more susceptible to hydrolysis, increasing the free fatty acid content over time **Adebayo *et al*. (2020).** The lower the acid value of an oil, the fewer free fatty acids it contains which makes it less exposed to the phenomenon of rancidification (**Roger et al., 2010)**. For an oil to be edible, the acid value is expected to range from 0.00–0.03mgO_2/g of oil. However, the values are high for the oils under study.

SAPONIFICATION VALUE: The high saponification values of the oils under study shows that more alkali would be required to enable it to neutralize the available free fatty acid liberated by the oil. The values are also indicative of a good soap forming abilities of some of the lipids. The soap forming abilities are in the decreasing order **Pumpkin> Melon > Palm kernel oil.**

Saponification value of an oil serves as important parameters in determining the suitability of oil in soap making. The higher the saponification value of oil the higher the lauric acid content of the oil. This shows that palm kernel oil is a better soap-making oil than pumpkin seed oil and melon seed oil due to its high saponification value. The saponification value shows palm kernel oil to be in the range of 240-261 (mgKOH/g of oil) as observed by **Boateng *et al.* (2021)**. The high value indicates the presence of short medium-chain fatty acids, making palm kernel oil ideal for soap and detergent production due to its lathering properties.
However, the saponification value of pumpkin seed oil ranges from 180 t0 200 mg KOH/g of oil. T**hakur *et al.* (2022)** reported that the oil's medium-chain fatty acid content makes it useful for both applications and cosmetics formulations, particularly for skincare products due to its emollient properties.

IODINE VALUE: The iodine value measures the degree of unsaturation in fat or vegetable oil (i.e the number of double bonds). It determines the stability of oils to oxidation as well as shows the overall unsaturation of fats to be determined quantitatively. Knowledge of the iodine value enables the combustion temperature of the oil to be evaluated **(Roger *et al.*, 2010]**. The iodine values obtained for palm kernel oil (50.97) classified the oil as non-drying oil due to its low iodine value as noted by **Boateng *et al.* (2021**). The low iodine value of palm kernel oil indicates that the oil is rich in saturated fatty acids such as lauric acid, which ensures stability against oxidation and rancidification of foods prepared with the oil. Comparing these iodine values, it can be deduced that pumpkin oil and melon oil are semi-drying oils because they have iodine values above 100 and thus contain some degree of unsaturation. **Kumari *et al* (2021)** noted that the unsaturated fatty acids, particularly linoleic and oleic acids make pumpkin seed oil beneficial to health, though it requires careful storage to prevent rancidity. The melon seed oil has similar iodine values ranging from 100 to 120g I_2/100g.

FREE FATTY ACID (%) (FFA): The percentage of free fatty acids (FFA) in pumpkin seed oil, melon seed oil, and palm kernel oil varies depending on factors such as extraction methods and oil storage conditions. Here's a summary of the reported values for each oil: Pumpkin (2.48%), melon (3.90%), and palm kernel (4.51%). The free fatty acid in pumpkin seed oil is reported to be generally low, around 1.2% to 3%. For example, **Kaur *et al*. (2023)** noted that the FFA content of pumpkin seed oil is approximately 1.2%. Which reflects its quality and freshness. Similarly, **Duenas *et al.* (2021)** reported similar FFA levels emphasizing that low FFA indicates good oxidative stability. Melon seed oil has a slightly higher FFA content, generally ranging from 2% to 4%. According to **Sadeghi *et al.* (2022)**, the FFA content in melon seed oil was found to be about 2.5%. This study indicated a FFA level of 3.9% which still falls within acceptable limits for edible oils. Palm kernel usually exhibits a higher FFA compared to the other two oils, with values ranging from 4 to 7%. **Azhar *et al.* (2021**) reported an FFA content of around 5% in palm kernel oil, which can be indicative of its processing and storage conditionals. The higher the free fatty acids, the higher the volatile components and acid value. Free fatty acids contribute to the bitter and soapy flavor in foods hence they are undesirable in edible oils and can be removed by refining processes.

FREE FATTY ACID COMPOSITION in PUMPKIN SEED OIL: Based on the result there are four prominent fatty acids and one alcohol present in pumpkin seed oil under study which includes capric acid (11.08%), lauric acid (6.17%), myristic acid (3.376%), myristol (43.571%) and oleic acids (35.799). It shows that oleic acid is the major fatty acid present in the oil under study. The dominant saturated fatty acid present in the oil is capric acid with a relative abundance of (11.08%). **Kumar *et al.* (2021)** reported that Linoleic ac9id was the predominant fatty acid (41-46%) followed by oleic (33.4-34.3%), in the pumpkin seed oil from Italy and Libya. The unsaturated fatty acids proportion is high, giving nutritional or dietetic properties to these oils. Saturated fatty acids contribute to increased cholesterol and predisposition to cardiovascular disease. Unsaturated acid is important because it prevents cardiovascular disorders such as coronary heart disease and atherosclerosis, and it prevents high blood pressure.

Conclusion

The extraction and characterization of vegetable oils from pumpkin seeds, melon seeds, and palm kernel nuts reveal significant differences in their physicochemical properties, which affect their usability in various industries. Pumpkin seed oil stands out for its low free fatty acid (FFA) content and high stability, making it suitable for both culinary and cosmetic applications (**Kaur *et al.*, 2023)**. Melon seed oil, with moderate FFA and good antioxidant properties, has promising nutritional and industrial applications **(Owen *et al.*, 2023**). Palm kernel oil, while having higher FFA content, remains a vital resource in the production of soaps, cosmetics, and other industrial goods due to its fatty acid profile **(Azhar *et al.*, 2021).** Overall, these oils present valuable resources due to their unique chemical compositions, including differences in specific gravity, melting point, and color characteristics, all of which influence their potential in food, cosmetics, and industrial applications.

Recommendations

- **Optimization of Extraction Methods**: To improve the yields and quality of oils from pumpkin seed, melon seeds, and palm kernel nuts, further research into refining extraction methods, such as cold pressing and solvent extraction, should be encouraged. This will help maximize yield while preserving the oil's beneficial properties.
- **Further Characterization Studies:** Detailed studies on the chemical composition and oxidative stability of these oils, especially in the context of their fatty acid profiles and antioxidant contents are needed. This will enhance their application in the health, beauty, and food industries
- **Storage and Preservation Techniques**: Since oils with higher FFA content, such as palm kernel oil, are prone to rancidity, improving storage conditions is critical to maintaining their quality over time. Research on effective preservation methods, such as the use of antioxidants, should be explored.
- **Utilization in Food and Cosmetics:** Pumpkin seed and melon seed oils, due to their beneficial fatty acid compositions and bioactive compounds, should be explored more extensively in the cosmetic industry and as functional foods. Their health benefits, including their anti-inflammatory and antioxidant properties, make them ideal candidates for future development

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