# Comparative Analysis of Physicochemical Properties of Oils from Groundnut, Melon, Watermelon and Orange Seeds

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## ABSTRACT

This study analyzed and compared the physicochemical properties of oils produced from groundnut, melon, watermelon and orange seeds. The moisture content, saponification value, iodine value, peroxide value, acid value, free fatty acid, ester value, refractive index, viscosity, density, specific gravity, cloud point, pour point, flash point and fire point of the oils were analyzed. There were no significant differences in iodine value, peroxide value, refractive index, viscosity, specific gravity, cloud point, pour point, flash point and fire point, while there were significant differences in the moisture content, saponification value, acid value, free fatty acid, ester value, and density, The results revealed that these oils contain low fatty acid value and they are good sources of edible oil as they have low acid value. These oils also have great potentials as industrially promising oils, with their high saponification and iodine values, they will be good raw materials for bio-lubricant production and for a variety of industrial applications.

**Keywords:** Physicochemical, oilseed, melon, watermelon, groundnut, orange seed

## INTRODUCTION

Vegetable oils derived from oilseeds have been playing vital roles to provide comfort in human lives in various aspects, they are essentially meeting the global nutritional demands and are utilized for many food and other industrial purposes. They had made important contributions to the diet globally, serving as a good source of protein, lipid and fatty acids for human nutrition repairing worn-out tissues, forming new cells as well as a useful source of energy [1]. Oilseeds are major sources of lipids for human diet and for several industrial purposes.

Oils from seeds and nuts constitute an essential part of man's diet with proteins, carbohydrates, vitamins and minerals. Nuts and oilseeds are receiving growing interest as they contain high concentration of bioactive lipid components which have shown various health benefits. Vegetable oils had made an important contribution to the diet in many countries, serving as a good source of protein, lipid and fatty acids for human nutrition including the repair of worn-out tissues, new cells formation as well as a useful source of energy. They are of important interest in various food and application industries providing characteristic flavors and textures to foods as integral diet components [1]. Oils and proteins derived from plant seed sources according to [2] are very essential for their nutritional, industrial and pharmaceutical applications.

In the last few decades according to [1], there have been growing concerns over vegetable oils as source of raw material in preference to petroleum or mineral oil. This is due to the environmental issues that regard mineral oil as major contributor of volatile organic components which themselves are responsible for most of our present recalcitrant pollution problems threatening the ecology. Oils can extensively be used in the food and also in the production of cosmetics, pharmaceuticals, biodiesel, bio-lubricant, paints and others. They serve as a source of oleochemicals which could replace a number of petrochemicals according to [3]. Reference [1] reported two quality types of oil: edible and non- edible oils. Edible oils are used as a food grade oil and ingredient in many food products, especially where a healthy oil is required, while non-edible oils are used industrially, they have been bred to contain high levels of compounds critical for some industrial processes. Edible oils are used as cooking oils or may be solidified (by a process called hydrogenation) to make margarine and shortening. Most edible oils are used in the food industry, but there is growing emphasis on industrial utilization of oils as feedstock for several industries. Non-edible oils are used in industry in the production of printing inks, paints, putty, varnishes, erasers, bio-lubricants, coating, bio-diesel, greases, plastics, etc. [25].

Groundnut, commonly called the poor man's nut, is an important oilseed and food crop in today's world. It is an important food, feed and principal oilseed crop which is cultivated on a large scale in some countries of the world. Groundnut is an upright or prostrate annual plant, generally distributed in the tropical, sub-tropical and warm temperate zones. It provides an inexpensive source of high-quality dietary protein and oil. Groundnut seed contains 44 to 56% oil and 22 to 30% protein on a dry seed basis and is a rich source of minerals (P, Ca, Mg and K) and Vitamins (E, K and B group) [4]. Its major component fatty acids are oleic acid (56.6%) and linoleic acid (26.7%). The oil also contains some palmitic acid, arachidic acid, arachidonic acid, behenic acid, lignoic acid and other fatty acids. It is an annual crop principally for its edible oil and protein rich kernel seeds, borne in pods which develop and mature below the soil surface according to [5]. The quality of the oil and groundnut products depends to a large extent on quality, the relative proportion of fatty acids, geographical location, seasons and growing conditions.

Melon belongs to the species of the genus *Citrullus* of cucurbitaceae family, which usually consists of a large number of varieties [6]. It is a creeping annual and intercropping plant which thrives well on the rich light soil. Melon is among oilseeds found in tropical Africa and it is cultivated for its seeds, which are rich in oil (53%), protein (28%) and some other important nutrients such as vitamin C and B2, minerals, riboflavin, fat and carbohydrates [7],[8]. Melon seed oil has golden yellow colour and is very rich in essential fatty acids (linoleic) but poor in linolenic acid, this therefore shows that the lower the linolenic acid content of oil, the more suitable is the oil for frying oil, making it good for the fight against cardiovascular diseases [7].

Watermelon, a vine-like flowering plant, is a member of the family of cucumber (*Cucurbitacea*). It is a drought tolerant crop which is cultivated chiefly in tropical, semi-tropical and rigid regions of the world. There are different varieties of watermelon and some of the varieties are: sugar baby, golden midget, star light, jubilee, yellow baby etc as reported by [9]. They have varying size (large or small) and shape (oval, round or oblong) as well as colour of the flesh (red, orange and yellow). The seeds have a high nutritive value and are a potential source of unsaturated fat, vitamins, antioxidants, minerals and proteins. They contain about 35% protein, 50% oil, and 57% dietary fibre. Some of the minerals found in these seeds are magnesium, calcium, potassium, iron, phosphorus, and zinc. Amino acid analysis of the seeds has shown that hydrophobic and acidic amino acids such as aspartic acid, glutamic acid, and serine dominated the composition of the protein fraction [9].

Orange (*Citrus sinensis*) is one of commonest fruits cultivated in the world. Reference [10] reported four kinds of orange across the globe which include blond orange of the Mediterranean, sugar or acidless orange, pigmented or blood orange and the navel orange. The common orange or blond orange of the Mediterranean is popularly called African sweet orange. The taste of the orange varies slightly across the continent due to location, handling and method of farming it. The fruits grow well in both the tropical and subtropical parts of the world. The fruit size also varies based on location and plant cultivation technique according to [11]. The shape of the fruit is spherical to oblong and its colour tints from green to light orange, depending on the cultivation technique used in the production of the fruit. Orange seeds are very rich in protein and contain 37% oil and 63% other substances other than the oil. The 37% oil content is fair compared to many other seeds such as mango seed kernel oil (19.8%) that are waste products of consumption or industrial processing of the fruits according to [12]. The oil from the orange seeds has been reported to be useful in the pharmaceutical, foods, textile and detergent industries. The seeds have been reported to be a good source of unsaturated fatty acids [13]. The major fatty acids present in orange seed oils are unsaturated fatty acids (palmitic, stearic, oleic, linoleic, and linolenic) and a large percentage of the total fatty acids of the seed oils. This makes the oil a desirable dietetic substitute for other unsaturated fats in food.

The physical value of oil depends upon its chemical composition; even today these values play a vital role while using different oil for industrial product according to [7]. This work studied and compared the physicochemical properties of oils from groundnut, melon, watermelon and orange seeds. The physicochemical properties of oils give a qualitative identification of oils and are very important in the selective application guide for the commercialization and utilization of oil products.

# MATERIALS AND METHODS

## Materials

Groundnut, melon, watermelon and orange seeds used for this work were collected from Wukari in Taraba State. The seeds were cleaned, manually dehulled and milled using milling machine. The oil was extracted in a soxhlet extractor using n-hexane as extracting solvent. All the solvents and reagents used for the analyses were of analytical grade and were obtained from the Food Chemistry Laboratory of the Federal University, Wukari.

## Methodology for Determination of the Physicochemical Properties

Moisture content

The method of [14] was adopted. The moisture content was obtained by using a known weight of the oil sample put into a clean previously weighed beaker and dried in an oven at 105°C for 4 hours. The sample was taken from the oven, cooled in a dessicator for about 30 minutes and then weighed. The procedure was repeated until a constant weight is obtained. The percentage moisture in the seed was then calculated using equation (1).

$$Moisture\ content\ (\%) = \frac{m_1 - m_2}{m_1}\ x\ 100 \qquad (1)$$

Where

$m_1 = mass\ of\ the\ test\ specimen\ before\ drying\ (kg)$

$m_2 = mass\ of\ the\ oven\ dried\ specimen\ (kg)$

Density and specific gravity

Oil of 5 ml was poured into a weighed beaker and weighed. The density was determined from the sample weight by taking the ratio of the weight of the oil to the known volume (5 ml) of the oil. Using the equation below:

$$\text{Density} = \frac{\text{sample mass}}{\text{sample volume}} \qquad (2)$$

$$\text{Specific density} = \frac{weight\ of\ a\ unit\ volume\ of\ the\ oil}{weight\ of\ equal\ volume\ of\ water} \qquad (3)$$

Refractive index

Refractive index of the oil was determined using [15] method. Abbes' refractometer was used for the measurement of the refractive index of the oil. The oil was smear on the lower position of the refractometer, after some adjustment the refractive index of the oil was read directly at room temperature ($28^oC$).

Viscosity

The viscosity was measured in accordance with [16]. This method covers the determination of viscosity using Smart series rotational viscometer TSML 21105. The viscosity was measured at room temperature ($28^oC$). At a start a proper viscometer spindle (3) was chosen. The samples were transferred to a beaker large enough to hold the viscometer spindle. The beaker was placed on a heating mantle set to a desired temperature, while the temperature of the samples was raised. The viscosity was read at the desired temperature. The viscosities of the oils were determined using equation (4) reported by [17]:

$$Viscosity = reading\ obtained\ x\ \frac{factor\ for\ the\ spindle}{speed} \qquad (4)$$

Saponification value
Saponification value was determined by weighing 1 gram of the oil into a flask and adding 25 $cm^3$ of 0.1 M alcoholic potassium hydroxide solution into the flask. A reflux condenser was attached and the flask was heated on a water bath for 1 hour with constant shaking. At the end of 1 hour the flask was removed from the water bath and 1$cm^3$ of the 1 percent phenolphthalein indicator was added. It was then titrated with the standard 0.5 M hydrochloric acid.

$$\text{Saponification value} = \frac{(V_2 - V_1)cm^3 x\ 26.05}{weight\ of\ oil}\ \text{(mgKOH/g)} \qquad (5)$$

Acid value
Acid value of the oil was determined by mixing 25 $cm^3$ diethyl-ether with 25 $cm^3$ ethanol in a conical flask and 1 $cm^3$ of 1 percent phenolphthalein indicator solution was added in accordance with ASTM D 664-18. The mixture was neutralized with 0.1 M potassium hydroxide solution then 1 gram of the oil was added to the neutralized solvent mixture. This was then titrated with 0.1 M potassium hydroxide solution. It was then shaken constantly until a pink colour which persists for 115 seconds was obtained.

$$\text{Acid value} = \frac{(V_2 - V_1)cm^3\ x\ 5.61}{weight\ of\ sample\ used}\ \text{(mgKOH/g)} \qquad (6)$$

Where: $V_1$ = sample titre value,

$V_2$ = blank titre value

Ester value
Ester value of oil is the number of milligrams required to saponify the ester contained in 1 gram of oil in accordance with AOAC (2000) method. The value was obtained as the difference between the saponification and the acid value.

Free fatty acids (FFA)
Free fatty acids were determined by weighing 1 gram of the oil samples into a conical flask. This was followed by the adding 10 $cm^3$ of neutralized 95 percent ethanol and Phenolphthalein. This was then titrated with 0.1 M NaOH, with constant shaking until a pink colour persisted for 30 seconds in accordance with AOAC (2000). The percentage free fatty acid was calculated from the equation (7):

$$\text{Free fatty acid (FFA)} = \frac{V\ x\ M\ x\ 2.82mg}{sample\ weight(g)} \qquad (7)$$

Where: V = Volume of NaOH,

M = Molarity of NaOH

2.82 = conversion factor of oleic acid.

**Peroxide value**

Peroxide value was determined using AOAC (2000) method by weighing 1 gram of the oil into a clean dry

boiling tube, 1 gram of powdered potassium iodide and adding 10$cm^3$ of the solvent mixture. The mixture was allowed to boil vigorously for 30 seconds. The tube was washed twice with 25 $cm^3$ portions of water and the washings were added to the titration flask. This was then titrated with 0.002 M Sodium thiosulphate using starch indicator. The relation for peroxide value is given as:

$$\text{Peroxide value} = \frac{(V_2 - V_1)cm^3 x\ Molarity of\ titrant}{weight\ of\ oil}\ x\ 100$$

(meqKOH/g) (8)

Where: $V_1$= sample titre value,

$V_2$ = blank titre value

Iodine value

Iodine value was determined using AOAC (2000) method by weighing 0.2 gram of the oil into a 250 $cm^3$ glass stopper flat, and adding 10 $cm^3$ of carbon tetrachloride to the oil and dissolved. 20 $cm^3$ Wijs' solution was equally added to the mixture and the content was corked with a stopper that initially moistened with potassium iodide solution. The mixture was titrated with 0.1 M standard sodium thiosulphate solution using starch as an indicator just before the end point.

$$\text{Iodine value} = \frac{(V_2 - V_1)cm^3 x\ 1.269}{weight\ of\ oil(g)}\ gI_2/100g \qquad (9)$$

Pour point and cloud point

Pour point and cloud point were determined using [18] method. The oil was poured into a test tube and placed into a refrigerator to solidify. The oil was removed after it solidifies and thermometer was used to read the temperature to which the solidified oil begins to melt and flow. The lowest temperature to which the movement is observed is the pour point. The cloud point is the temperature at which a cloud of wax crystals first appear when the oil was cooled.

Flash point and fire point

The flash point measurement was done according to [19]. The oil was poured into a metal container and heated at 5$^o$C interval with a flame being passed over the surface of the sample. The temperature at which an instantaneous flash occur was taken immediately and recorded as a flash point. The fire point is that temperature at which the vapour of the oil burns constantly for 5 seconds when flame is brought near.

## RESULTS AND DISCUSSION

The physicochemical properties of oils from groundnut, melon, watermelon and orange seeds are shown in Table 1 and Figures 1 - 7.

Table 1: Physicochemical properties of oils from sandbox seed, melon and watermelon seed

| **Ppties** | **Grdnut** | **Melon** | **Watermelon** | **Orange** |
|---|---|---|---|---|
| M/Ct (%) | 0.40$^a$ | 0.40$^a$ | 0.40$^a$ | 0.23$^b$ |
| Density (g/$cm^3$) | 0.86$^b$ | 0.85$^b$ | 0.82$^b$ | 0.91$^a$ |
| Specific gravity | 0.93$^a$ | 0.91$^a$ | 0.85$^b$ | 0.90$^a$ |
| Refractive index | 1.464$^a$ | 1.470$^a$ | 1.463$^a$ | 1.470$^a$ |
| Viscosity at 28$^o$C (cSt) | 54.10$^a$ | 47.29$^b$ | 44.54$^c$ | 40.98$^d$ |
| Saponification value (mgKOH/g) | 195.20$^a$ | 170.66$^b$ | 155.24$^c$ | 169.48$^b$ |
| Acid value (mgKOH/g) | 1.96$^{bc}$ | 2.00$^b$ | 1.83$^c$ | 5.42$^a$ |
| Ester value (mgKOH/g) | 183.46$^a$ | 168.92$^b$ | 152.79$^d$ | 163.91$^c$ |
| Free fatty acid (mgKOH/g) | 9.79$^a$ | 9.98$^a$ | 8.96$^b$ | 5.82$^c$ |
| Peroxide value (meqKOH/g) | 1.28$^b$ | 1.27$^b$ | 1.07$^b$ | 3.72$^a$ |
| Iodine value ($gI_2$/100g) | 176.36$^a$ | 135.73$^c$ | 162.02$^b$ | 156.37$^b$ |
| Pour point ($^o$C) | - 6.63$^c$ | - 4.15$^a$ | - 5.25$^b$ | -4.75$^{ab}$ |

| | | | | |
|---|---|---|---|---|
| Cloud point (°C) | 9.50[a] | 7.75[b] | 6.75[b] | 7.50[b] |
| Flash point (°C) | 329.00[b] | 339.00[a] | 348.50[a] | 329.00[b] |
| Fire point (°C) | 333.00[b] | 343.50[a] | 347.00[a] | 332.50[b] |

Values are means of 2 replications. Means with different superscripts within a row are significantly different ($p<0.05$).

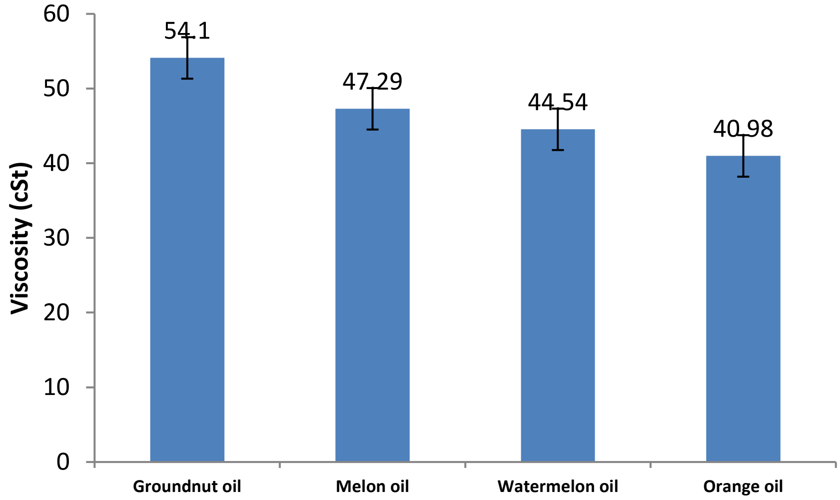


Figure 1: Viscosities of the oils at 28°C

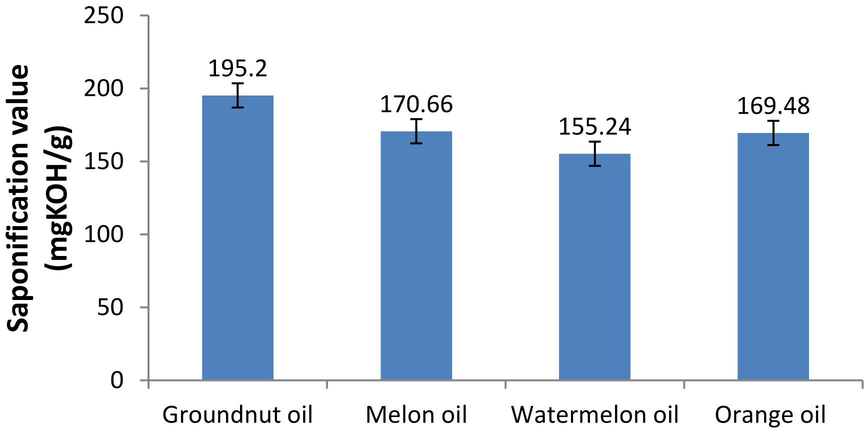


Figure 2: Saponification values of the oils

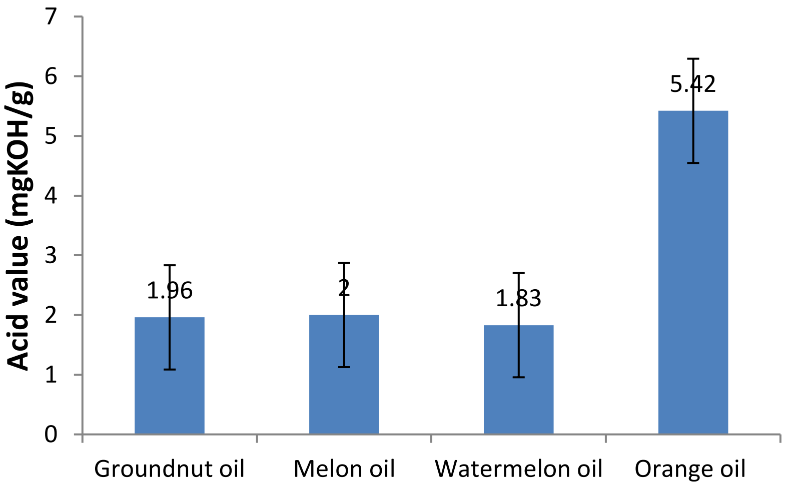


Figure 3: Acid values of the oils

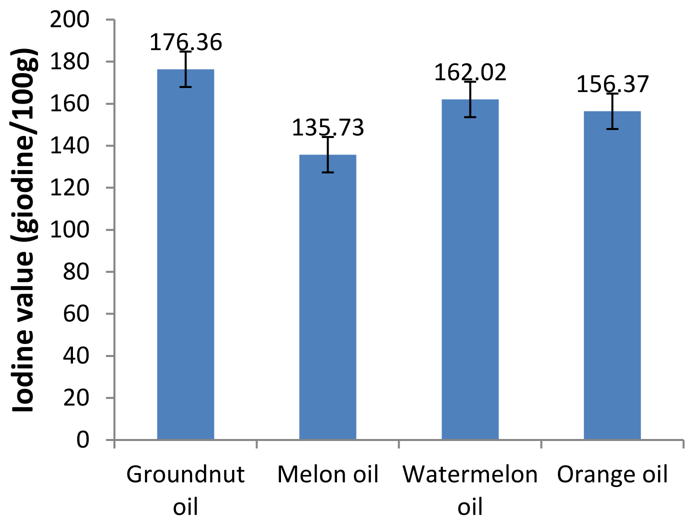


Figure 4: Iodine values of the oils

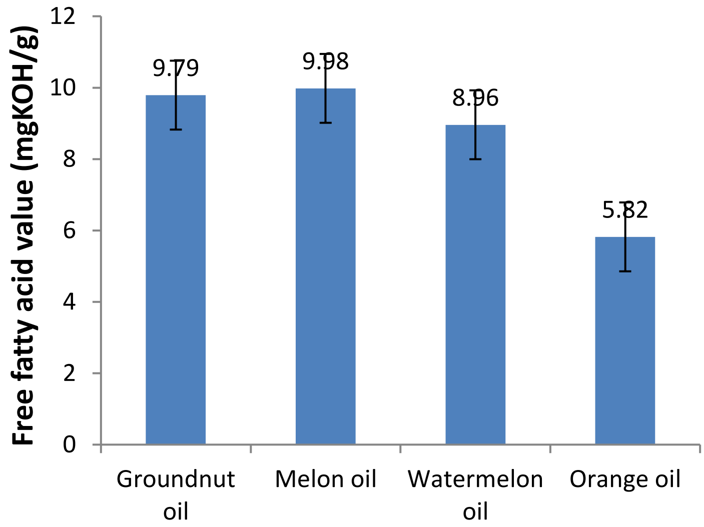


Figure 5: Free fatty acid values of the oils

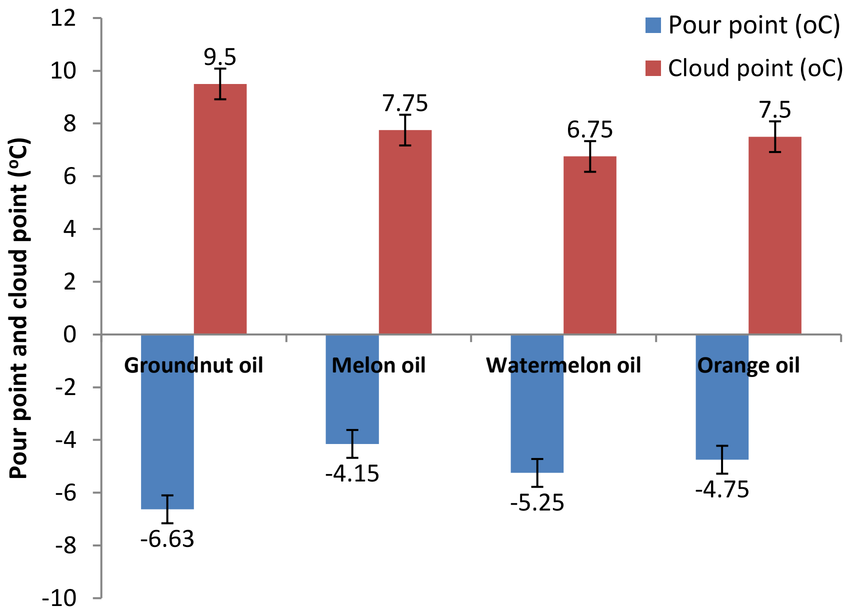


Figure 6: Pour and cloud points of the oils

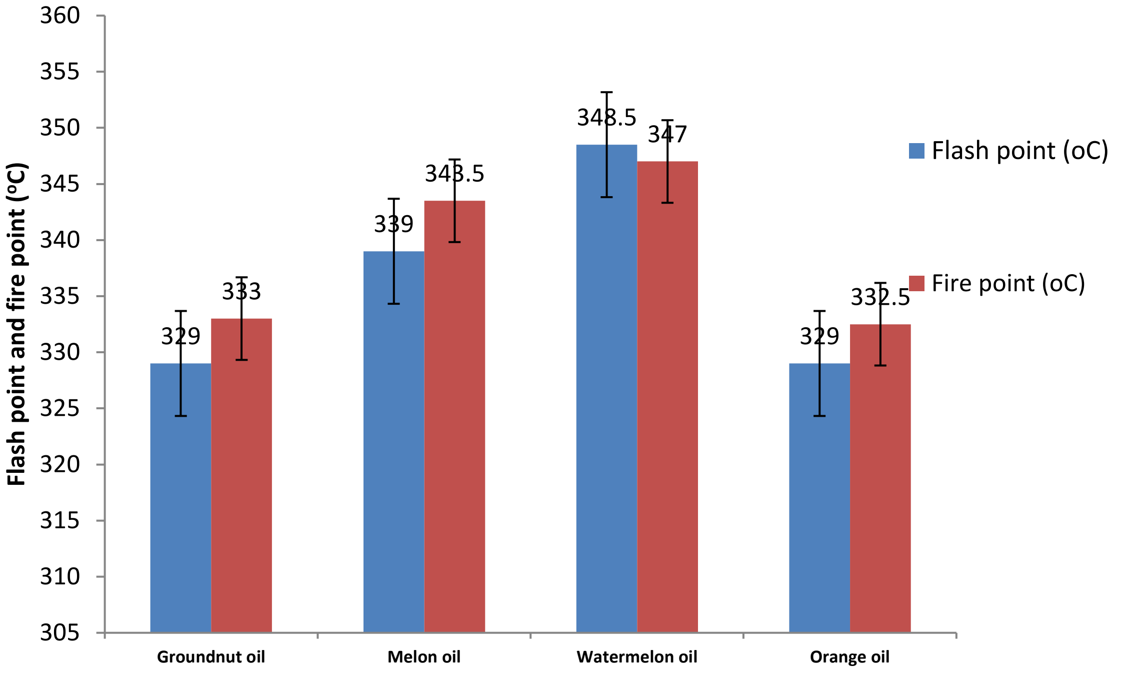


Figure 7: Flash and fire points of the oils

**Moisture content**

There was no significant difference (p>0.05) in the moisture contents of the groundnut oil, melon oil and watermelon oil, while there was significant difference in that of orange oil (P<0.05) compared to other oils as shown in Table 1. The moisture content of the groundnut, melon and watermelon oils was 0.40 % while that of orange oil was 0.23% which were within allowable limit of 0.1% - 0.5% for vegetable oils as reported by [14]. These values according to [20] show that the oils will have a longer shelf-stability as it will not easily give in to hydrolysis and ease of attack by oxygen. The lower the water content, the better the quality of the oil, this is because the water in the oil can trigger a hydrolysis reaction which causes a decrease in the quality of the oil due to an increase in free fatty acid levels [21]. The presence of water in oil according to [22] increased the oxidation progress and which result in to premature oil aging. Therefore low moisture content in oil is a requirement for long storage life as oil with low moisture content is expected to be more stable during storage than oils with high values. Orange oil when compared with the other oils will be more stable and last longer during storage.

**Density and Specific gravity**

The range of the densities of the oil samples was 0.82 – 0.91 and these values fall within the standard range of common oils as approved by the Standard Organization of Nigeria [23]. The range of the specific gravities of the oil samples was 0.85 – 0.93, specific gravity is influenced by the chemical composition of the oils. According to [24], the density of oil is dependent on their fatty acid composition, minor component and temperature. There was no significant difference (p>0.05) in the densities of the groundnut oil, melon oil and watermelon oil, while there was significant difference (p<0.05) in density of the orange oil when compared with other oils as shown in Table 1. Also, there was no significant difference (p>0.05) in the specific gravities of the groundnut oil, melon oil and orange oil, while there was significant difference (p<0.05) in specific gravity of the watermelon oil compared to other oils.

Reference [25] stated that the specific gravity suitable for edible oils range from to 0.87163 to 0.93136 and for oils used for fuel from 0.8114 to 1.0714 at room temperature. An increase in the amounts of aromatic compound of the oil results in an increase in the specific gravity, while an increase in the saturated compounds results in a decrease in the specific gravity. According to [26], specific gravity is commonly used in conjunction with other figures in assessing the purity of oil. The density and specific gravity values of the oils showed that they are less dense than water. Hence, in case of contamination with water, water will settle below the oil and will be subsequently drained off. Orange oil is the densest oil when compared with groundnut, melon and watermelon oils. The specific gravities obtained are in the range found for common oils as reported by [27].

**Refractive index**

The degree of refraction of a beam of light that occurs when it passes from one transparent medium to another is known as the refractive index. It is the ratio of speed of light at a defined wavelength to it speed in the oil. It varies with wavelength and temperature, the degree and type of unsaturation, the type of substitutions of component fatty acids and with accompanying substances. It is used to check purity and to follow and control hydrogenation and isomerization processes [25]. According to [1], refractive index indicates the level of saturation of the oil and is widely used in quality control to check for the purity of materials and to follow hydrogenation and isomerisation. There was no significant difference ($p>0.05$) in the refractive indexes of the oils as shown in Table 1. The values range from 1.463 – 1.470, which were within the acceptable range of 1.4677 to 1.4707 for virgin, refined and refined-pomace oils reported by [1]. These values showed that the oils are less thick when compared with most oils whose refractive indices were between 1.480 and 1.490 reported by [28]. These values are satisfactory as they lie within the standard range found in common oils reported by [27]. The values obtained are also in close agreement with the values obtained by [29] for common oils.

**Viscosity**

Viscosity is important in the design of process equipment, heat transfer equipment, process piping design and pressure drop determination. It is one of the critical properties of oil. There were significant differences ($p<0.05$) in the viscosities of the oils at room temperature (28$^o$C) as shown in Table 1 and Figure 1. The viscosity of groundnut oil was 54.10 cSt, melon oil was 47.29 cSt, watermelon was 44.54 cSt while that of orange oil was 40.98 cSt. These values are agreement with the viscosity values of some common oils reported by [28]. The results showed that groundnut oil is more viscous than other oils. The more viscous oil is, the better it use for industrial purposes according to [1]. Oils are mixtures of triglycerides and their viscosity depends on the nature of the triglycerides present in the oil. Oils with low viscosity values are light and probably highly unsaturated. The viscosity of oils, according to [30] depends on molecular structure and decreases with the unsaturation of fatty acids. The viscosity changed due to the different arrangement of the fatty acids on the glycerol backbone of the triglyceride molecule.

**Saponification value**

Saponification value gives an indication of the molecular weight of the fatty acid contained in the oil and the purity status of the oil or whether the oil is adulterated [31]. It measures the oxidation during storage and indicates deterioration of the oils. Saponification value according to [1] enhances the quality of the oil because it shows the presence of lower molecular weight components in 1 gram of the oil which will yield more energy on combustion. High saponification values suggest that the oil has little impurities.

The saponification value of groundnut oil (195.20 mgKOH/g) was significantly high when compared with the values for melon oil (170.66 mgKOH/g), watermelon oil (155.24 mgKOH/g) and orange oil (169.48 mgKOH/g) as shown in Table 1 and Figure 2. These values indicate that these oils contained high proportion of free fatty acids. The reason being that saponification value is said to have strong positive correlation with free fatty acids content. Reference [28] reported that oils with higher saponification values contain high proportion of free fatty acids. Reference [32] also reported that the higher the free fatty acids, the higher the saponification value and vice versa. The presence of high saponification values which indicate the presence of high percentage of free fatty acids might lead to foam formation. Foaming is a desired characteristic of good surfactants with applications in preparation of emulsions, soaps and detergents formulation according to [33]. This suggests that these oils can be used in production of soaps, shampoos, lather saving creams, paints and bio-lubricants [31]. There could also be an extension to their application into stable foam by incorporation of other ingredients. Therefore, these oils may enjoy usage in many other industrial applications.

### Acid value

Acid value is defined as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids present in one gram of fat. Acid value, according to [31], measures the amount of free fatty acids which have been liberated by hydrolysis from the glycerides due to the action of moisture, temperature and/or lypolytic enzyme lipase. It is also a relative measure of rancidity as free fatty acids are normally formed during decomposition of oil glycerides. It is an important indicator of vegetable oil quality. Acid value gives an indication of the deterioration, rancidity, or edibility of the oil. It is used as an indicator for edibility of an oil and it suitability for use in industrial applications [1]. The lower the acid values of the oil, the higher the quality. High acid levels imply that the oil will require an excess polyol for its polycondesation reaction. There was significant difference ($p<0.05$) in the acid values of the oils as shown in Table 1 and Figure 3. The acid value of orange oil (5.42mgKOH/g) was higher than that of the groundnut oil (1.96 mgKOH/g), melon oil (2.00 mgKOH/g) and watermelon oil (1.83 mgKOH/g). These values falls within the range of 0.34 – 68.88 reported by [1] for common oils. According to [25] oil that is low in acidity is suitable for consumption, acidity less than 0.1mgKOH/g is usually the best. The acid values of the oils were low which indicates that the oils were in good non-degraded state of the lipids and were within limits for industrially useful oils [34] This is very good because oils with low acid value are useful industrially in the manufacture of lubricant, paint and varnish [14]. Low acid values in oils indicate that the oils will be stable over a long period of time and protect against rancidity and peroxidation.

### Free fatty acid

The free fatty acid profile of oils plays an important role in their stability and nutritional value. It is the value of specified fatty acid in oil and it is an index for determining the quality of oils. The lower the free fatty acid content, the more desirable is the oil as edible oil. It is recommended that edible oil should have free fatty acid values of less than 5% as such oils has lower tendency to go rancid [31]. Oils with substantial amounts of unsaturated fatty acids are susceptible to oxidation. Reference [1] reported that the quantity of free fatty acid in oil is an indicator of its overall quality; high quality oils are low in free fatty acids. Reference [35] reported that oil with low free fatty acid has lesser susceptibility to rancidity. An excessive amount of free fatty acids lowers the flash point of oil and will cause 'popping' of the oil during heating. The free fatty acid concentrations of the oils were low which were consistent with the low acid values obtained. The free fatty acid values of the oils range from 5.82 to 9.98, which are around the free fatty acid values of common oils reported by [1]. There was significant difference ($p<0.05$) in the free fatty acid concentration of the oils as shown in Table 1 and Figure 5. Melon oil had highest free fatty acid concentration (9.98 mgKOH/g), followed by groundnut oil (9.79 mgKOH/g) and watermelon (8.96 mgKOH/g), while orange oil had the lowest concentration (5.82 mgKOH).

### Peroxide value

Peroxide value is used to determine the extent to which oil can go rancid as a result of storage, heating or oxidation. It is the most common indicator of lipid oxidation and gives an indication of the quality and stability of oil. According to [1], high peroxide values indicate high levels of oxidative rancidity of the oils and also suggest absence or low levels of antioxidant. Rancid oils have peroxide values of 10 – 20 meqKOH/g oil and the Standard Organization of Nigeria (SON) recommended peroxide values for edible oils is 10 meqKOH/g oil as reported by [31]. The peroxide value of the oils were found to be at the range of 1.07 – 3.72 meqKOH/g, which is low and falls within the standard range of 2 – 10 meqKOH/g reported by [36]. Watermelon oil had lowest peroxide value (1.07 meqKOH/g) when compared with groundnut oil (1.28 meqKOH/g), melon oil (1.27 meqKOH/g) and orange oil (3.72 meqKOH/g). There was significant difference ($p<0.05$) in the peroxide values of the oils as shown in Table 1. The low peroxide values recorded for these oils classified them as edible, more saturated and less prone to rancidity. This indicates that the oils are stable to oxidative rancidity and can stand oxidative degradation.

### Iodine value

Iodine value is a measure of degree of unsaturation of fats and oils and could be used to quantify the amount of double bond present in the oil which reflects the susceptibility of the oil to oxidation. It is also the measure of the drying property of oils. Iodine value is used as a basis for the classification of fats and oils into drying (with iodine value higher than 150 g $I_2$/100g), semi-drying and non-drying (with iodine value of the range 100 - 150 g $I_2$/100g) and non-drying (with iodine value lower than 100 g $I_2$/100g) oils as reported by [31]. High iodine value means high degree of unsaturation fats and oils. Saturated oils and fats have zero iodine value because they cannot take up any iodine [31]. The higher the iodine value, the less stable, softer, more reactive and susceptible to oxidation the oil will be. According to [1], the lower the iodine value the lesser the number of unsaturated bonds; thus the lower the susceptibility of such oil to oxidative rancidity. Reference [32] reported that oils with high iodine value have lower melting point and perform better in cold weather. There was significant difference ($p<0.05$) in the iodine values of the oils, with groundnut oil having highest value (176.36 g$I_2$/100g), followed by watermelon (162.02 g$I_2$/100g) and orange oil (156.37 g$I_2$/100g) while melon oil had lowest value of 135.24 g$I_2$/100g as shown in Table 1 and Figure 4. These iodine values suggested that the oils are good drying oil; a good drying oil should have iodine value of 130 and above [1]. The iodine value of the oils was high, owing to the fact that the oils contain unsaturated glycerides, which have the ability to absorb a definite amount of iodine and can be used for the production of lubricant, paint and alkyd resin. Oils whose iodine value is between 100 – 150 according to [37], possess the property of absorbing oxygen on exposure to the atmosphere, become thicken and remain sticky but do not form a hard dry film and they can be used in the production of margarine and soap.

**Pour and cloud points**

Pour point is the lowest temperature at which movement was observed while cloud point is the temperature at which a cloud of crystals first appear when the lubricant is cooled. Viscosity, according to [25], influences the pour point of oils; the higher the viscosity the lower the pour point. Pour points of the oils range from -4.15$^oC$ to -6.63$^oC$; while cloud points of the oils range from 6.75$^oC$ to 9.50$^oC$ as shown in Table1 and Figure 6. Low temperature fluidity according to [38] is the most essential property for oils to perform in environments that are extremely cold.

**Flash and fire points**

The flash point is the temperature at which an instantaneous flash occur when flame is brought near the oil while the temperature at which the vapour of the oil burns constantly for 5 seconds is the fire point. Fire point is always flash point plus 5$^oC$ up to 400$^oC$. The flash points of the oils range from 329$^oC$ to 348.5$^oC$, while the fire points range from 332.5$^oC$ to 347$^oC$ as presented in Table 1 and Figure 7. It is clear from the results obtained that the oils have very good flash and fire points as they can be used in both humid and temperate regions and transported safely with minimum risks of explosion. These values are similar to the values reported by [39].

## CONCLUSION

The physicochemical properties of the oils studied revealed that they are all in the range of both edible oils and bio-fuel synthesis. The results therefore suggest that the oils have many edible and industrial attributes. The low viscosities of these oils would make them useful in frying, cooking and in the production of bio-fuels. The results showed that groundnut oil is more viscous than melon, watermelon and orange oils and has little impurities. Orange oil will be more stable and last longer during storage compared to other oils. Their low iodine value classified them as non-drying oil could be used in the manufacture of soaps, body creams, cosmetics, plasticizers and lubricants. The low peroxide values indicate that the oils are stable to oxidative rancidity and can stand oxidative degradation. The findings of the current work would be useful for future studies to investigate the fatty acid profile of the oils.

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