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Solvent Extraction and Characterization of Oil from Coconut Seed Using Alternative Solvents

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Abstract— **Solvent extraction and characterization of oil from coconut seed using alternative solvents have been studied. The solvents used were Isopropanol and Petroleum ether. The Physicochemical parameters of the extracted oil was determined by standard methods of analysis. The percentage oil extracted were 94.7 and 72 for isopropanol and petroleum ether respectively. Also, the acid, peroxide (mg/peroxide/kg), saponification (mgKOH/goil) and iodine (mg iodine/100g) values were 0.156 and 0.156, 0.45 and 0.55, 262 and 261, 9.4 and9.3 for isopropanol and petroleum ether respectively. Both solvents demonstrated similar properties in all the analysis.**

Isopropanol and petroleum ether are therefore alternative solvents to the traditional Hexane

***Index Terms*— Isopropanol, Hexane, petroleum.**

I. INTRODUCTION

Oil constitutes a well-defined class of neutral organic substance which are essential constituent of all forms of plant and animal life. They are soluble in organic solvent except water. The most important characteristic is that they have a caloric content more than twice as high as the other food stuff. [1]. The only possible way of obtaining large quantity of oil from oil bean vegetable or plant material is by extraction. According to [2], bio-oils from oilseeds are used as Straight Vegetable Oil (SVO) or as biodiesel (transeterified oil) depending on type of engine and level of blend of the oil; coconut oil is not an exception. Generally, oils and fats from seeds and nuts constitute an essential part of man's diet. The plants and animals that produce oils and fats in plentiful quantities and a sufficiently available form for it to be an article of commerce are comparatively few .The larger source of oils at present is the seeds of annual plants. Fats and oils, together with proteins, carbohydrates, vitamins and minerals, are the main nutrients required by the human body. Fats and oils are rich sources of energy, containing two and a half times the calories of carbohydrates (per unit weight). In addition to being a source of vitamins A, D, E and K, fats and oils also contain essential fatty acids. . Edible seeds and nuts noted for their oil contents include palm nut, coconut, soya bean, olive, groundnut, sunflower seed, and cottonseed, while non-edible seeds and nuts include jatropha seed, neem seed, and castor seed.

Coconut is an edible oil extracted from the kernel of matured coconut palm. It is a source of fats in diet of many homes and has various applications in food, medicine and industries [3]. Coconut is extracted by dry and wet process. In spite of various techniques, wet processing is less viable than dry processing due to a 10-15% lower yield [4]. Conventional coconut oil uses hexane as solvent to extract up to 10% more oil from just using rotary mills and expellers. Many health organizations advice against the consumption of high amounts of coconut oil due to its high levels of saturated fat [5,6] . Coconut oil is commonly used in cooking, it has been tested for use as a feedstock for biodiesel and can also be used as skin moisturizer, helping with dry skin [7,8] .
Increasing the extraction of oil to meet the rising demand for vegetable oils in different industries requires a suitable solvent which is readily available in the country at a relatively cheaper cost to replace hexane, which is considered hazardous, expensive and occasionally scarce based on demand and cost of petroleum. This study therefore, sought to provide a fair idea on a possible solvent replacement using isopropyl alcohol and petroleum ether for hexane in the extraction of Coconut oil giving a clear indication as to the best options and requirements for higher optimum oil recoveries from coconut using these two solvents.

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II. Materials and Methods

2.1 Sample Preparation

Cocos nucifera was purchased from Choba market in Port Harcourt , Nigeria.. The coconuts was dishelmed and washed, size reduction was carried out by manual grating to get fine particles of uniform size particle.

2.2 Extraction Procedure

100g of sample A was weighed into a filter paper of known weight. Wrapped sample sealed and put in the receiver tube of the extractor. The filter paper played the role of a thimble. 300ml of isopropanol was poured into solvent flask. The receiver tube was connected to the soxhlet flask with the aid of adapter to make it air tight.

A flux condenser was connected to the soxhlet tube. The set up was held up with a clamp and is mounted on the heating mantle. The flux condenser was connected to a water reservoir and water flows constantly through the condenser and heating mantle was switched on. isopropanol boiled at 82^{o}C and its vapour was condensed by the reflux condenser. The condensate drips on the wrapped sample and gradually percolates it while the oil is absorbed by the solvent. The mixture goes up with time to the tip of the extractor discharge, at this point solvent is refluxed into the flask. This process continues till a colourless condensate is notice which indicates no trace of oil then heating process is stopped. The mixture of oil and solvent is kept to cool. After cooling, sample was removed from the receiver and the condenser connected back to the receiver tube.

The mixture was distilled and isopropanol was recovered and the oil showed no traces of isopropanol present. For further purity, distilled oil was transformed into a beaker and heated. As boiling began to boil isopropanol was evaporated till pure oil was left. Heater was turned off and oil was cooled.

This process was repeated for sample Busing petroleum ether as the solvent.

2.3 Determination of the Physicochemical Properties

Standard methods [9] was used in all the analysis

2.3.1 Determination of the percentage yield of oil

This is the quality of oil extracted in a specific time relative to the weight of the melon sample used. This was done according to the solvent used for the extraction.

This is determined at the end of extraction applying this equation:

$$\textit{Percentage yield} = \frac{\textit{Weight of oil extracted}}{\textit{Weight of seed sample}} \times \frac{100}{1}$$

2.3.2 Determination of specific gravity

The mass of given volume of sample oil was determined

$$\frac{\text{Weight of oil extracted}}{\text{Weight of equivalent water}} \times \frac{100}{1}$$

The empty density bottle was weighed and recorded. The dry density bottle was filled with sample A. When the temperature had reached the ambient temperature at which the measurement is to be made, the volume of the oil was adjusted to the fixed mark and when a density bottle was used, care was taken to insert the stopper of the density bottle in such a way that the capillary action is completely filled with the oil. The weight of the density bottle together with the oil is taken and recorded as W_2

$$\textit{Specific gravity} = \frac{\textit{Density of oil}}{\textit{Density of water}}$$

2.3.3 Determination of peroxide Value

30ml of acetic acid chloroform solution was measured into a flask containing 2g of the oil sample. A 0.5ml saturated solution of potassium iodide was then added, followed closely by the addition of 30ml of distilled water. The flask content was then titrated against 0.1M $Na_2S_2O_3$ until the yellow color disappeared. 0.5ml starch indicator was added and the titration continued until the end point (where the blue colour just disappeared). A blank titration was also performed.

2.3.4 Determination of acid value

A solution of 25ml each of diethyl ether and ethanol was prepared and 2.0g of the sample oil was added, and the mixture was digested in a water bath for ten minutes. It was then titrated still hot with 0.1M of NaOH solution until the pink colour fades.

Under the same condition, a blank titration was conducted. Acid vale is determined:

$$= \frac{\text{titre value x N x 56.1}}{\text{Weight of sample}}$$

2.3.5 Determination of pH

pH value indicates the level of acidity or alkalinity of a sample:

A buffer solution prepared with distilled water was used to calibrate pH meter. The probe was rinsed for the sample considered at the point of no change in reading.

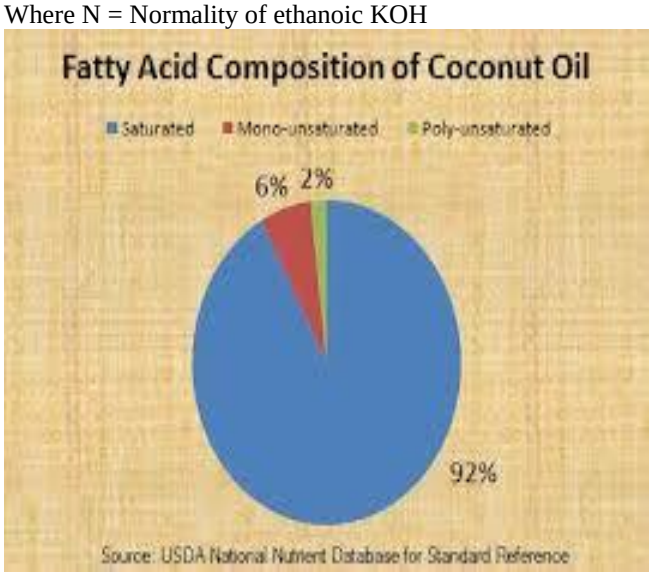
2.3.6 Determination of free fatty acid (ffa)

Free fatty acids are formed during decomposition of glycerides in oil. The FFA value is the number of milligrams of KOH required to neutralize 1g of the oil.

100g of the sample of oil was weighed

$$\%FFA = \frac{\text{Titration value x N x 28.2}}{\text{Weight of sample}}$$

Where N = Normality of ethanoic KOH



2.3.7 Determination of Saponification value

25ml of ethanoic potassium hydroxide solution was measured into a round bottom flask and 2.0g of sample oil was dissolved in it. A reflux condenser was attached to the flask and it was heated in a water bath for an hour, 7ml phenolphthalein solution was added and kit was titrated against 0.5M Hydrochloric acid solution to a point where the pink colour disappeared. A blank titration was also carried out as control the saponification value was calculated using this relation.

$$SV = \frac{BS \times 0.5M \times 56.1}{\text{Weight of sample}}$$

Where B = blank titre value
S = sample titre value

2.3.8 Determination of Iodine value

Iodine value is expressed as the degree of unsaturation of oils and fats.
2g of the sample oil was dissolved in a 500ml flask by 20ml of carbon tetrachloride and minutes. 20ml of potassium iodide was added followed by 100ml distilled water. The solution was titrated with standard 0.1M $Na_2S_2O_3$ solution while shaking well till the pink colour disappearing on adding starch. A blank titration was also carried out.

$$\text{Iodine value} = \frac{B - S \times 0.1 \times 12.69}{\text{Weight of sample}}$$

Where 12.69 is a constant
B = blank titration
S = sample titration

3. Results and Discussion

The results obtained from various experiments are presented below:

Table 3.1 Percentage oil yield

	Isopropanol	Petroleum ether
Particle size (um)	0.1	0.1
Volume (ml)	300	300
Mass (g)	100	100
Oil yield (%)	94.7	72

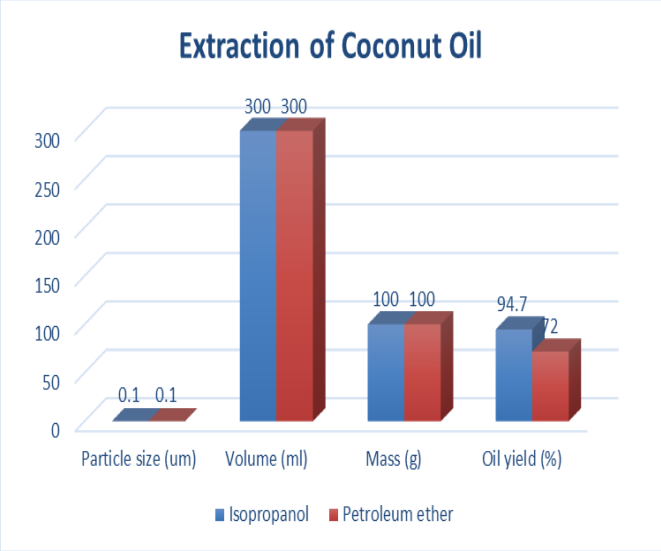


Table 3.2: Physical Properties of the Extracted oil with The Different Solvents

S/ no	Properties	Isopropyl Alcohol	Petroleum ether
1.	Colour	Colourless	Colourless
2.	Specific gravity	0.92	0.93
3.	Moisture Contents (%)	0.3	0.2
4.	Melting point (oc)	25	25.6
5.	Odour	Smell of coconut	Smell of coconut
6.	Density(kg/m3)	916.24	924.26
7.	Solubility in Water	Insoluble in water at room temperature.	Insoluble in water at room temperature.
8.	State	Solid at room temperature	Solid at room temperature

Table 3 .3: Chemical Properties of the Extracted oil

S/no	Properties	Isopropyl Alcohol	Petroleu m ether
1.	Acid value	0.156	0.156
2.	Peroxide value (meg peroxide/kg)	0.45	0.55
3.	Saponification value (mgKOH/gs oil)	262	261
4.	Iodine value (mg iodine/100g)	9.4	9.3
5.	Free fatty acid	0.1	0.1

3.2 Discussion

Tables 3.1 -3.3 present the physicochemical properties of oil extracted from cocosnucifera using isopropyl alcohol and petroleum ether as the solvent.

Solubility

Cocos nucifera oil forms a white homogenous mixture when beaten well in water, otherwise it is insoluble in water at room temperature.

Specific gravity

The specific gravity are 0.92 and 0.93 for isopropyl alcohol and petroleum ether respectively. this implies that both oils are less dense than water.

Colour

The colour of the oils was colourless above 30^0C, white when in solid form and the result of the melting point was 25^0C.

Melting point

The melting point shows the temperature at which a fat or oil starts to melt as each oil has its own melting point which is dictated by its chemical composition. The melting point of 25^0C is in the range of 25-26^0C,which is codex standard for cocos nucifera oil.

Moisture content

The moisture content of food gives an indication of its shelf life and nutritive value, hence low moisture content is a requirement for long storage life. from the table above it can be seen that coconut oil has a low moisture content which accounts to its long shelve life.

Odour

The odour of both samples of oil was that of a coconut smell because they were not refined ,bleached or deodorized.

Free fatty acid content

Free fatty acid is the percentage by weight of a specified fatty acid. high concentrations of free fatty acids are undesirable in crude oils because they result in large losses of the neutral oil during refining. Hence, the free fatty acid obtained from this work were 0.1 and 0.1 for isopropyl and petroleum ether solvents respectively, this values implies low rancidity of the oil and thus viable as edible oil.

Iodine value

The results of the iodine value were 9.4 and 9.3mg iodine 100g. The iodine value is a measure of the unsaturation of fats and oils and its is an indicator of double bindings in the molecular structure in terms of classification of fats and oils. Cocos nucifera oil is non-drying with an iodine value lower than 100.

Peroxide value

The peroxide value is an index of rancidity, thus indicates a poor resistance of the oils to peroxidation during storage. The peroxide values of 0.45 and 0.55meg peroxide/kg for isopropyl alcohol and petroleum ether respectively which are below the maximum acceptable value of 10 meg peroxide/kg signifies its high oxidative stability.

Saponification value

The saponification values were 262 and 261 mg koh/g oil for isopropyl alcohol and petroleum ether respectively compared favourably and within the range for edible oils reported by codex standards for coconut oil.

III. Conclusion

Oil was extracted from Cocos nucifera using isopropanol and petroleum ether as solvent. The oil extract were subjected to physicochemical properties measurement. The result obtained from the analysis where found to be within literature value as was recommended by WHO values for edible oils. The analysis also show that percentage oil yield where 94.7% and 72% for isopropanol extract and petroleum ether extract respectively .Both solvents demonstrated similar characteristics in all the analysis Conclusively, Isopropanol is preferred to petroleum ether and can be recommended as alternative solvent to Hexane.

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