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EFFECT OF EXTRACTION METHODS ON SOME PHYSICOCHEMICAL PROPERTIES AND FATTY ACID PROFILE OF OIL FROM TWO PALM FRUITS (*Cocos nucifera* L) AND (*Elaeis guineensis*)

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Abstract:

Coconut oil and palm kernel oil are edible plant oil obtained from the kernel of palm fruits and coconut fruit respectively. They are used for commercial cooking, cosmetic and pharmaceutical industries. This study was aimed at evaluating the physicochemical properties and fatty acid profile of palm kernel oil (PKO) and coconut oil (CO) extracted using different extraction methods. The kernels were obtained, cracked open, crushed and the oil extracted using hot, cold and solvent for both oils in addition to local roasting for PKO. Samples from each extraction method were collected and analyzed for physicochemical properties including; density, viscosity, refractive index, oil yield, moisture content, iodine value, peroxide value, saponification value and acid value. Phytochemical and fatty acid composition of each sample was analyzed using GC-MS. The results of the studies indicate that, for both oils, there was no significant difference using different methods in acid, peroxide and iodine values. Hot method had the highest oil yield while moisture was highest in the cold extraction for both oils. GC-MS results for PKO showed a total of 23 compounds in different organic families among which were seven fatty acids, five of which were present in all the four oil samples. GC-MS analysis for CO identified 22, 20, and 31 compounds in cold, hot, and solvent extracted oils, respectively. Seven fatty acids were identified of which four of the fatty acid acids were present in all the oil samples. n-Decanoic acid was present only in cold, while Nonadecenoic acid and Erucic acid were present only in solvent extraction. The study concludes that extraction method significantly influences the yield, stability, and composition of coconut and palm kernel oils, with hot extraction producing more stable oil and solvent extraction providing a broad range of bioactive compounds useful for food, cosmetic, and pharmaceutical applications. From the findings, it was concluded that, extraction methods affected the number and type of phytochemicals present in the different oils.

Keywords: Extraction methods; Palm kernel; Coconut; Oils; Physicochemical; Fatty acids.

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INTRODUCTION:

Palm tree is any member of the *Arecaceae*, or *Palmae*, the single family of monocotyledonous flowering plants of the order *Arecales*. It is widely distributed across the globe, with great centers being America, Asia and Africa. There is high concentration in the tropical, subtropical, and warm temperate climates. It derives its name in different languages from "palm of the hand;" so called from the shape of its leaves, like fingers of a hand. There are approximately 2,600 known species of palm trees, with ongoing botanical research potentially changing this number. They exhibit a wide diversity in their forms, growing as trees, shrubs, or even climbers. They are characterized by unbranched stems and large, evergreen leaves, called fronds. Fronds can be pinnate (feather-like) or palmate (fan-like). [1]

The palms with the greatest importance in world commerce are coconut (*Cocos nucifera* L) and the African oil palm (*Elaeis guineensis*). The two are the prime sources of vegetable oil and fatty acids. Coconut (*Cocos nucifera* L) has been described as the most important and extensively grown palm tree worldwide providing food for millions of people especially in the tropical and sub-tropical regions. The most important coconut producing countries in the world include the Philippines, Ceylon, India, Malaysia, Oceania and parts of West Africa including Nigeria.[2] Every part of the plant is useful, and in many ways support human life. For years, coconut has been produced in Nigeria for human consumption while in some countries in the world it is one of the economic legacies. Coconut fruit is a very important fruit because of the nutritional value and the critical role that it plays in improving food security in the world. It is classified as a 'functional' food. Due to the healing properties and health benefits, coconut fruit is of special interest beyond its nutritional content, especially in traditional medicine. It is used in the alleviation of asthma, bronchitis, dysentery, flu, irregular or painful menstruation, ulcers and kidney stones.[3] In medicine, it is recognized for its antimicrobial properties and has been investigated for its potential role in managing conditions such as Alzheimer's disease, cardiovascular diseases, and diabetes. [4]

Coconut oil (CO) is a versatile natural product derived from the kernel or meat of coconut and is widely utilized in various industries, including food, cosmetics, and pharmaceuticals. It is composed mainly of medium-chain fatty acids, including lauric acid, capric acid, caprylic acid, myristic acid, and palmitic acid, which contribute to its antimicrobial, antioxidant, and anti-inflammatory properties. [3]

Palm kernel oil (PKO) is a versatile natural product derived from the kernel of the oil palm fruit *(Elaeis guineensis)*, widely cultivated in tropical regions such as Nigeria, Malaysia, and Indonesia. As a major agricultural product, palm kernel oil plays a significant role in the food, cosmetic, and pharmaceutical industries due to its rich composition of saturated and unsaturated fatty acids, notably lauric acid, which constitutes approximately 48–52 % of its fatty acid profile. [5] The oil is valued for its stability, high melting point, and functional properties, making it a preferred ingredient in margarine, confectionery, soaps, and skincare products. Palm kernel oil's high lauric acid content contributes to its antimicrobial and anti-inflammatory properties, making it valuable in pharmaceutical formulations. [6] Additionally, its medium-chain fatty acids are rapidly metabolized, providing quick energy and potential benefits in weight management and cardiovascular health when consumed in moderation. [7]

The extraction methods of both coconut and palm kernel oils plays a crucial role in determining the physicochemical properties of the oils, and the fatty acid profile of the final product, which ultimately affects its quality, stability, and effectiveness in various applications. [8] The physicochemical properties of oils are critical quality indicators that determine their stability, purity, and suitability for various applications. Viscosity is an essential parameter that influences the oil's flow

characteristics and its application in formulations such as creams and lotions. The refractive index provides insight into the purity and composition of the oil, with variations indicating the presence of impurities or degradation. The peroxide value is a measure of lipid oxidation, with higher values indicating increased rancidity and reduced shelf life. The acid value represents the level of free fatty acids in the oil, which affects its taste, stability, and quality. A lower acid value is desirable, as it indicates minimal hydrolysis and a longer shelf life. The iodine value is used to assess the degree of unsaturation in the oil, which influences its drying properties and stability. [9, 10]

These properties are significantly influenced by the method of extraction employed. Examining the effects of extraction methods on the physicochemical properties of the oils is essential in understanding how different processing techniques impact the quality, alter the oil's nutritional profile, stability, fatty acid composition and sensory attributes. [11]

This study investigates the effects of different extraction methods: hot, cold, solvent extraction and local roasting on the physicochemical properties and fatty acid profile of palm kernel and coconut oils, aiming to identify the most suitable method for specific applications.

MATERIALS AND METHODS

Materials: All the reagents used in the research were sourced from distributors in Port Harcourt in Rivers state, Nigeria and were all of analytical grade.

Methods:

Collection and preparation of raw materials: Fresh and mature coconut fruits and palm kernels were obtained from the monastery farm in Madonna University Elele, Rivers state Nigeria. The palm kernels were cleaned, de-husked, and about 2 Kg was crushed using a hand miller to obtain a fine particles. The coconut were de-husked and crushed using a Q-link China Model blender.

Extraction procedures:

Local roasting method: The uncrushed palm kernels 500 g was placed in a dry pot and roasted over high temperature (gas flame) for 30 - 60 minutes till the oil became visible. [12] The pot was brought down and the oil was decanted while still hot. This process was done in batches till enough quantity of oil for the experiment was obtained. The oil was bottled in a clean container and labeled roasting extraction (PKR). [13]

Hot extraction method: The method of Mba *et al*, 2015 was used with some modification. [14] The crushed palm kernel powder 500 g was washed with hot water to obtain the kernels milk. The extracted milk was then sieved with a fine sieve to separate the kernel husk from the milk. The milk was then boiled using a big beaker until the oil showed on the surface. The extracted oil was carefully skimmed off and placed in a clean bottle and labeled as hot extraction (PKH) and stored for further analysis. Hot extraction for coconut oil was according to the method of Manikantan *et al*., (2016). [15] The oil was extracted by heating coconut milk obtained from 500 g of coconut meat at 100-120 °C for 60 minutes until the water was completely evaporated. Due to heating, the proteins in coconut milk get denatured and destabilizes the milk emulsion. The oil was separated from coagulated protein by filtering through muslin cloth. The oil was stored in clean sample bottles and labelled (COH).

Cold extraction: The crushed palm kernel powder 500 g was washed with hot water and the milk was sieved with a fine sieve to remove the kernels chaff. The milk was refrigerated for 24 hours to obtain a caked palm-kernel oil which was collected and melted in a water bath at 40 ^{o}C till the oil separate from the water. An aspirator pipette was used remove the oil and stored in a clean bottle and labeled as cold extraction (PKC). [16] For coconut, cold extraction was done according to the method of Raghavendra and Raghavarao (2010) with some modifications. Coconut milk obtained from 500 g of coconut meat was centrifuged at 5000 rpm for 10 minutes at 4 °C and the upper layer of cream was removed for chilling. Chilling was done at 4 °C for 24 h and then the chilled cream was thawed slowly in a water bath at 40 °C. The oil was filtered through muslin cloth and stored in glass bottles and labelled (COC). [18]

Solvent extraction method: The crushed palm kernel powder sample 500 g was mixed with 750 mL of n-hexane in a beaker, stirred, and left to stand for 2 hours for extraction of the oil. The mixture was filtered into a beaker, covered with perforated aluminum foil and left overnight for the solvent to evaporate. The oil was aspirated using aspirator pipette and stored in a glass bottle labeled as solvent extraction oil (PKS). [19] For the coconut, 500 g of fresh coconut meat was blended with a hand mill to obtain the coconut milk. The solvent 750 mL of n-hexane was transferred into a large beaker containing the palm kernel milk. The content in the beaker was stirred and covered with an aluminum foil and allowed to stand for 2 hours for the extraction of the oil. The mixture was filtered into a beaker and covered with perforated aluminum foil and left overnight for evaporation of the solvent. The oil was filtered, stored in clean bottle and labeled (COS). [18, 19]

Analysis of physicochemical parameters

Density measurement: Density bottle 25 mL were washed, rinsed with acetone, allowed to dry and

weighed. The weight of the empty bottles were determined (W1). The density bottles were filled with test samples to the fluidicial mark and the weight determined (W2). The density bottle was cleaned, dried and filled with Carbon free water and weighed on analytical balance and the weight recorded as W3. Relative density was calculated as (W2 - W1) / (W3 - W1) x 100 / 1. [20, 21]

Refractive index measurement: The refractive indices of the oil samples were determined at 20 ºC using the Abbe refractometer. Each oil sample was separately introduced into the prism surface and the required field was adjusted using the knob and readings recorded. [16, 22]

Viscosity measurement: Viscosity was determined at 20 °C using an NDJ-5S viscometer with a number 3 spindle at 6, 12, 30, and 60 rpm. The sample was stirred for 1 minute until the reading stabilized. [11, 23]

Acid value measurement: The test samples weighing 0.5 g was dissolved in 20 mL of a mixture of methanol and ether in a ratio of 1:1, and 3 drops of phenolphthalein solution was added as an indicator and titrated using 0.1 M solution of potassium hydroxide solution. A blank determination was carried out without the test sample and the acid value and percentage free acid calculated using the equation: Acid value = (Titer value of oil sample / Weight of sample) x 56.1 [20, 23]

Peroxide value measurement: The test samples weighing 0.5 g were dissolved in 10 mL chloroform and 15 mL glacial acetic acid and 1 mL 10 % saturated potassium iodide solution was added to the content of iodine flask, shaken, allowed to stand for 1 minute in the dark and 30 mL of distilled water was added and titrated to a faint yellow colour with 0.01M sodium thiosulphate solution and 1 mL of starch indicator added towards end point (a mL). A blank determination was carried out (titration b mL) and the peroxide value determined. [24]

Iodine value measurement: The test samples weighing 0.5 g each were placed into a dry 250 mL iodine flask and 10 mL of chloroform was added to dissolve the sample and 20 mL of 0.1M iodine monochloride was added and the mixture was kept in the dark for 30 minutes, 25 mL of 10 % potassium iodide solution and 100 mL of distilled water were added. The liberated iodine was titrated using 0.1M sodium thiosulphate and starch mucilage was added towards end point as indicator. A blank determination was carried without the test sample. [20, 21]

Saponification value measurement: The test samples each weighing 0.5 g was dissolved in 25 mL of 1.0 M KOH (aq) and refluxed on a boiling water bath for 1.0 hour. It was cooled and back titrated the excess KOH with 1.0 M Hydrochloric acid (a mL) using phenolphthalein as the indicator and blank determination was carried out by omitting the test sample (b mL). The titration was carried out in duplicate and the saponification values calculated with formula [21, 24]

Saponification value = [(Titre value of blank – titre value of oil sample) x 28.05]/Weight of oil sample

Moisture content determination: The moisture content of the oil samples was determined using the oven-drying method. Exactly 5 grams of each oil sample was weighed into a pre-dried and weighed crucibles. Two crucibles for each oil sample were washed, dried and weighed (Wi). The different oil samples (5 g) were weighed into separate crucibles and placed in an oven at a temperature of 105°C for 180 min after which they were left in desiccators to dry and weights retaken (Wf). This protocol of drying, cooling and weighing was continuous until a constant weights of the oils were obtained. The loss in weight was recorded, and the moisture content was calculated as a percentage of the initial sample weight (%) = [(Wi – Wf) x 100 / 1 [20]

Oil recovery: The oil recovered was calculated based on the oil recovered from the palm meat/milk from different extraction methods and represented as the percentage of the initial weight of the test samples.

Gas Chromatography-Mass Spectrometer (GC-MS) Analysis: The oil samples from different extraction methods for both coconut and palm kernel were subjected to GC-MS analysis. The carrier gas was helium and the oven temperature range of 80 – 3000 ºC at time 5 – 15 minutes. The MS was taken at 70eV with a total run time of 20 minutes for each sample. Identification of compounds was done by comparing them with known compounds in the institute's samples library. [6]

RESULTS:

Physicochemical Properties: The physicochemical properties of the coconut oil from different extraction methods is represented in table 1, while table 2 is for oils from palm kernel.

Table 1: Physicochemical properties of extracted coconut oil samples

Test	Oil Type		
	COC	COH	COS
Percentage oil recovery (%)	15±0.001	23±0.003	18±0.003
Relative Density (g/mL)	0.9152 ± 0.02	0.9112 ±0.01	0.9039 ±0.02
Viscosity (mPa.s)	66.7 ± 2.00	66.7 ± 2.00	65.5 ± 3.00
Refractive index	1.4896 ±0.01	1.4895 ±0.01	1.5205 ±0.02
Moisture content	0.43 ±0.01	0.19 ±0.02	0.35 ±0.02
Peroxide value	0.04±0.01	1.40±0.02	0.03±0.01
Acid value (MeqKOH/g)	4.70±0.02	3.10 ±0.01	2.60 ±0.01
Iodine value (g/100g)	4.01±0.02	7.64±0.01	3.61±0.01
Saponification Value (MgKOH/g)	0.028±0.01	0.053±0.01	0.021±0.01

Table 2: Physicochemical properties of extracted palm kernel oil samples.

Test	Oil Type			
	PKC	PKH	PKR	PKS
Percentage oil recovery (%)	24.40±0.001	33.20±0.003	33.20±0.003	32.80±0.003
Density (g/mL)	0.909 ± 0.02	0.896 ±0.01	0.886 ±0.02	0.895 ±0.02
Viscosity (mPa.s)	32.15 ±2.00	40.80±2.00	38.41±2.00	28.83±1.00
Refractive index	1.499 ±0.01	1.502 ±0.01	1.504 ±0.01	1.499 ±0.01
Moisture content	0.44 ±0.02	0.34 ±0.01	0.29 ±0.01	0.42 ±0.02
Iodine value (g/100g)	51.65±0.02	45.30±0.01	34.30±0.01	5.51±0.12
Acid value (MeqKOH/g)	5.69 ±0.02	6.82±0.02	6.88±0.02	7.29±0.02
Peroxide value	2.55±0.01	2.72±0.02	2.75±0.02	2.646±0.01
Saponification Value (MgKOH/g)	195.93 ±0.14	195.79 ±0.11	195.89 ±0.42	195.51 ±0.3

GC-MS characterization for palm kernel: The GC-MS chromatograph of palm kernel oil using cold, hot, roasting and solvent extraction techniques are presented in Figure 1, 2, 3 and 4, while results of the phytoconstituents are depicted in Tables 3.

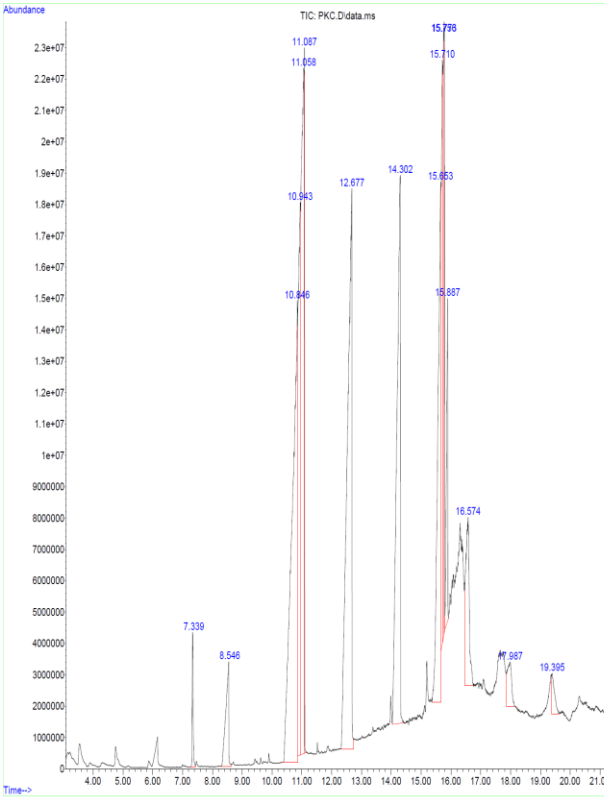

Figure 1: GC-MS Chromatograph for PKC

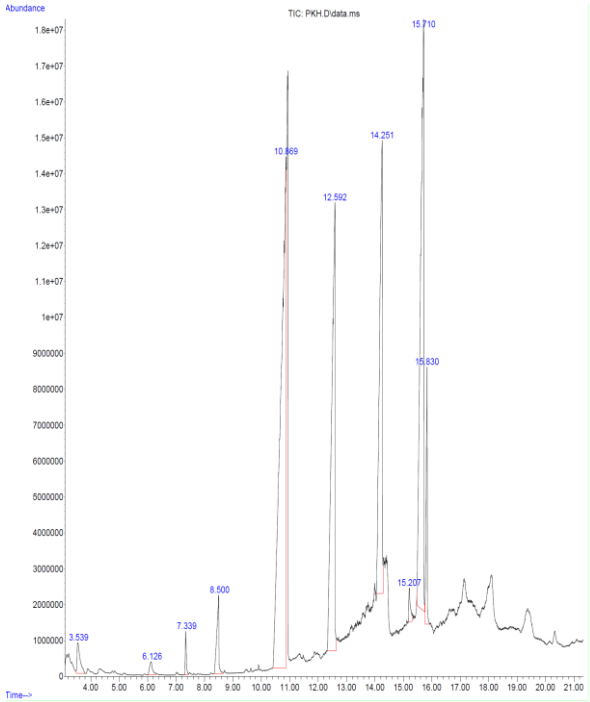

Figure 2: GC-MS Chromatograph for PKH

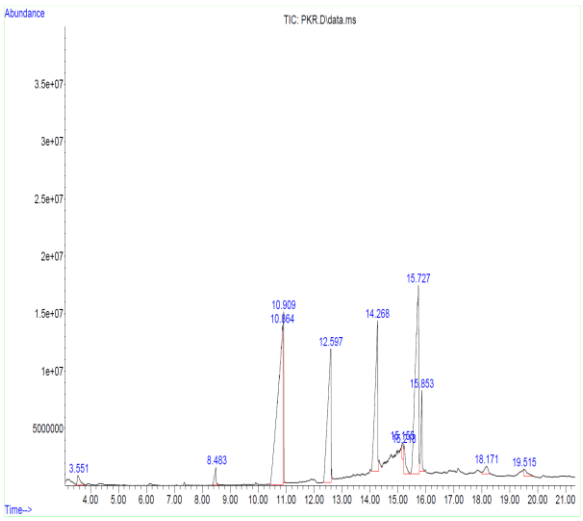

Figure 3: GC-MS Chromatograph for PKS

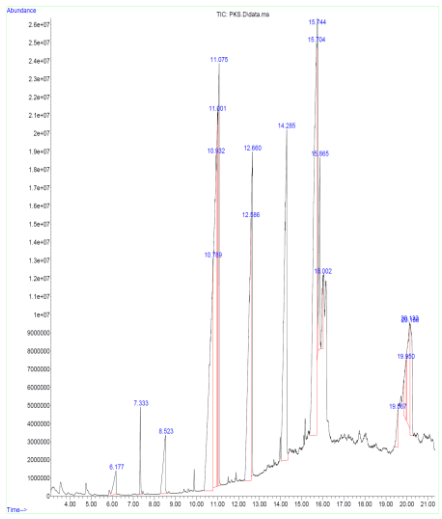

Figure 4: GC-MS Chromatograph for PKR

Phytoconstituents: The results of the phytoconstituents in oil samples using cold, hot, roasting and solvent extraction techniques are presented in Tables 3

Table 3: Phytoconstituents of the extracted palm kernel oil samples

Phytoconstituents	Oil Sample			
	PKC	PKH	PKR	PKS
Octanoic acid (caprylic acid)	-	+	-	+
2-Undecanone	+	+	-	+
n-Decanoic acid (capric acid)	+	+	+	+
Dodecanoic acid (lauric acid)	+	+	+	+
Tetradecanoic acid (myristic acid)	+	+	+	+
n-Hexadecanoic acid (palmitic acid)	+	+	+	+
9-Octadecanoic acid (oleic acid)	+	+	+	+
Octadecanoic acid (stearic acid)	-	+	-	+
Tetracosane	-	-	+	+
9-Octyl Eicosane	-	-	-	+
Docosan 5-butyl-	+	-	-	+
Octacosan	-	-	-	+
Nonadecane				
1-Iodohexadecane	-	-	-	+
	-	-	-	+
Eicosane	-	-	-	+
Docosan-9-butyl	-	-	-	+
9-Octyl-Heptadecane	+	-	-	+
Squalene	+	-	+	-
1,2,3-Trimethyl benzene (mesityiene)	-	+	+	-
Total	9	9	8	17

Fatty acids present: The results of the fatty acid in the palm kernel oil samples using cold, hot, roasting and solvent extraction techniques are presented in Table 4

Table 4: Fatty acids content in the extracted palm kernel oil samples

S/N	Fatty acid	Molecular formula	Oil Samples			
			PKC	PKH	PKR	PKS
1	Octanoic acid (caprylic acid)	$C_8H_{16}O_2$	-	+	-	+
2	n-Decanoic acid (capric acid)	$C_{10}H_{20}O_2$	+	+	+	+
3	Dodecanoic acid (lauric acid)	$C_{12}H_{24}O_2$	+	+	+	+
4	Tetradecanoic acid (myristic acid)	$C_{14}H_{28}O_2$	+	+	+	+
5	Hexadecanoic acid (palmitic acid)	$C_{16}H_{32}O_2$	+	+	+	+
6	9-Octadecenoic acid (oleic acid)	$C_{18}H_{32}O_2$	+	+	+	+
7	Octadecanoic acid (stearic acid)	$C_{18}H_{36}O_2$	-	+	-	+

GC-MS characterization for coconut oil: The GC-MS chromatograph of coconut oil using cold, hot and solvent extraction techniques are presented in Figure 5, 6 and 7, while results of the phytoconstituents are depicted in Table 5.

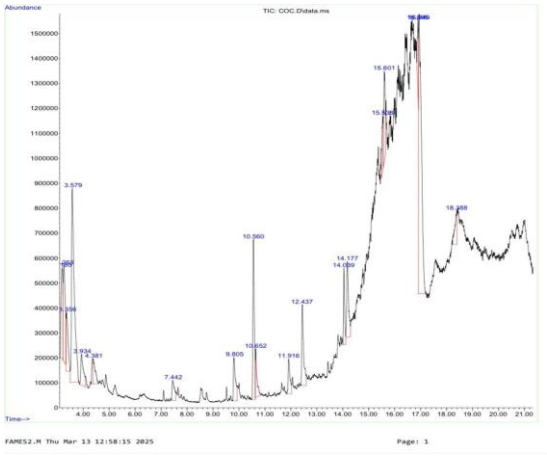

Figure 5: GC-MS Chromatograph for COC

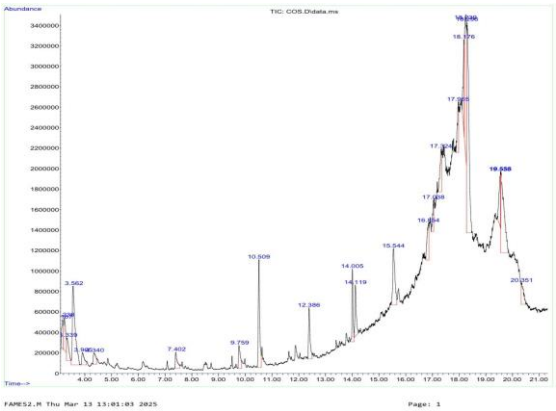

Figure 6: GC-MS Chromatograph for COH

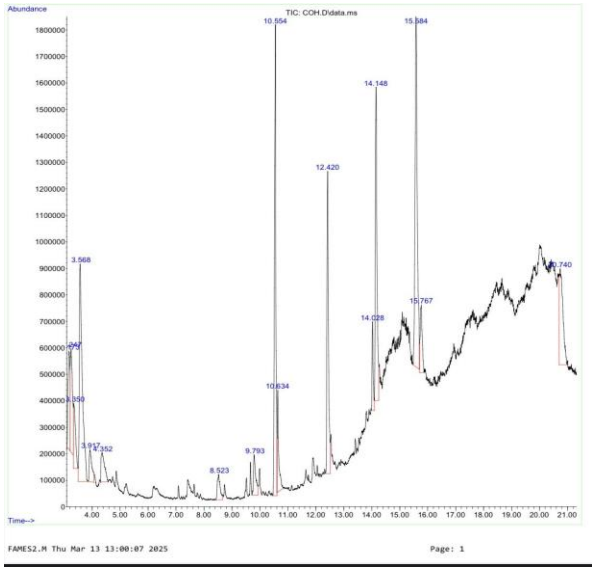

Figure 7: GC-MS Chromatograph for COS

Table 5: Phytoconstituents of the extracted coconut oil samples

Phytoconstituents	Oil Samples		
	COC	COH	COS
1-Ethyl-2-methyl benzene	+	+	+
1-Ethyl-3-methyl benzene	+	+	+
1-Ethyl-4-methyl benzene	+	+	+
1,2,3-trimethyl benzene	+	+	+
1,3,5-trimethyl benzene (Mesitylene)	-	-	+
N-Methyl-2-Pyrrolidone	-	-	+
2,7-Dimethyloctane	-	-	+
n-caproic acid vinyl ester	-	-	+
3-methyl-isoxazole-5(4H)one	-	-	+
2H-Pyran-2-one tetrahydro-6-pentyl	-	-	+
2H-Pyro-2-onetetrahydro-6-propyl	-	-	+
Dodecanoic acid (Lauric acid)	+	+	+

Tetradecanoic acid (Myristic acid)	+	+	+
Dibutyl phthalate	-	+	+
Phthalic acid hept-4-yl isobutyl ester	-	+	+
n-Hexadecanoic acid (palmitic acid)	+	+	+
Cyclotetracosane	-	-	+
n-Nonadecenoic acid (nonadecylic acid)	-	-	+
9- Octadecenoic acid (oleic acid)	-	+	+
Tetracosane	+	-	+
1-chloro-Heptacosane	-	-	+
Heptadecane	+	-	+
Tritetracontane	+	-	+
Carbonic acid,eicosyl vinyl ester	+	-	+
Tridecane, 6-propyl	-	-	+
Bacchoticuneatin C	-	-	+
9-Butyl docosane	-	-	+
7-Hexyl docosane	-	-	+
11-Deyl docosane	-	-	+
Hexacosane	-	+	+
Squalene	-	-	+
Lauric anhydride	-	+	-
Octadecan-1-ethenyloxy	-	+	-
Phthalic acid	-	+	-
Decanoic acid (capric acid	-	+	-
1-methyl-2-pyrolidinone	+	+	-
Ethyl-heptanoate	+	+	-
2-Methoxythiophene	+	-	-
1-Pyrrolidinecarboxaldehyde	+	-	-
TOTAL			

Table 6: Fatty acids content in the extracted coconut oil samples

S/N	Name of Fatty acid	Molecular formula	Oil Samples		
			COC	COH	COS
1	Dodecanoic acid (lauric acid)	$C_{12}H_{24}O_2$	+	+	+
2	Tetradecanoic acid (myristic acid)	$C_{14}H_{28}O_2$	+	+	+
3	Hexadecanoic acid (palmitic acid)	$C_{16}H_{32}O_2$	+	+	+
4	9-Octadecenoic acid (oleic acid)	$C_{18}H_{32}O_2$	+	+	+
5	n-Decanoic acid (capric acid)	$C_{10}H_{20}O_2$	-	+	-
6	Nonadecenoic acid (nonadecylic acid)	$C_{19}H_{38}O_2$	-	-	+
7	Erucic acid	$C_{20}H_{42}O_2$	-	-	+

DISCUSSION:

Oil yield: In palm kernel roasting method gave the highest oil yield (33.28 ± 0.003%), followed by solvent extraction (28.73 ± 0.003%), hot extraction gave (27.22 ± 0.003%) and cold (24.40 ± 0.002%). The trend was similar in coconut, with solvent giving the highest (23±0.003%), followed by hot (18±0.003) and then cold. The higher yield in local extraction method in PKR is attributed to heat reducing oil viscosity, facilitating extraction. [14, 25] Solvent extraction's higher yield in both is due to the solvent's ability to penetrate meat matrices. [19] The oil yield is consistent with the average oil yield reported in the literature, which states that most plant seeds contain about 22- 45 % of oil on dry matter basis. Oil yield may be affected by variety differences and other pretreatments of the seed before extraction. [26] Cold extraction, while producing less oil, preserves bioactive compounds, aligning with findings by Ogbunugafor *et al.* 2011. [16]

Moisture content: Oil quality is greatly influenced by moisture content. According to APCC regulations, the moisture content of the edible oils should be less than 0.5%.[27] Analyzing the moisture content of oils is essential for understanding the quality of such oils. High moisture content lead to hydrolytic rancidity of fats and oils and reduces the shelf life of oils. [18] For coconut, hot extracted oil had the least moisture content (Table: 2), this may be due to the high temperature that significantly remove the water components from the sample. Considering the allowable 2 % moisture content limit for vegetable oils, all the extracted oil samples were within this limit. Moisture content of oils is a necessary parameter when considering the storage of oils. This is so because, oils that have higher moisture are liable to deterioration which could be due to microbial growth and have poor taste owing to rancidity. In this study, the methods employed did not adversely affect the water content of the oil samples thus guaranteeing their long shelf life. [24]

Density of the Oil samples: Density of oils is a useful parameter for the measurement of adulteration and this is directly related to temperature and the fatty acid components. Edible oils are expected to be less dense than water. The purity of the oil is determined by its density or specific gravity. The presence of a higher value of fatty acid found in the oil increases the specific gravity or density of the oil. No significant ($p>0.05$) difference was observed in the densities of all the oils with the different extraction methods (tables 2 and 3). The fact that all the extracted oil samples exhibited density lower than that of water could make them good oils for culinary purposes. [24]

Refractive index: The refractive index is the degree of refraction of a beam of light that occurs when it passes from one transparent medium to another. Refractive index is unique for oil and is used to check adulteration and purity of oils. The refractive index values of vegetable oils are pegged by NAFDAC at 1.45-1.46 and also, by JOSC at 1.44-1.47. The refractive index value obtained in this study ranged from 1.49 to 1.50 for palm kernel oils and 1.49 to 1.52 for coconut oil. There was no significant difference ($p>0.05$) in all the oil samples. Refractive index for all the oil samples were within standard values. [11, 28]

Viscosity: Viscosity is a critical parameter in food production because it usually affects the texture, appearance and stability of food products. Viscosity control usually leads to delicious taste of food products. The viscosity of the oils from both palm kernel and coconut from the different extraction methods did not vary significantly (Table 1 and 2).

Acid value: The acid value indicates the level to which the glycerides in the oil had been decomposed by lipase action. According to CODEX (2011), the acid value must be lower than 6.6 mgKOH/g for good quality coconut and palm kernel oil. [19, 29] The acid value of the coconut oil samples from the different extraction methods ranged from 2.60 to 4.70 mg/KOH/g. The cold oil extraction had the highest acid value (4.70±0.02 mg/KOH/g) followed by the hot extraction (3.10±0.02mgKOH/g). The acid value of the palm kernel oil samples (Table 2) ranged from 5.69 to 7.29 mg/KOH/g. PKS had the highest acid value (7.29 mg/KOH/g) followed by the PKR oil (6.82 mgKOH/g). These values are higher than the CODEX standard possibly due to solvent interaction and the heat used in PKR. [19]

Saponification value: Saponification is a measure of the milligrams of KOH required to saponify 1.0 g of oil sample and it is a useful parameter in the production of soap. The World Health Organisation (WHO) recommends that edible oils should have less free fatty acid not exceeding 1.37 % since their release encourages rancidity. CODEX (1991) sets the standard for saponification value at 248 to 265 mgKOH/g of oil, while National Agency for Food, Drug Administration and Control (NAFDAC) sets it at 190 – 209. Both oils extracted by different methods, Table 2 and 3 did not encourage the release of fatty acid and the saponification values obtained are within the range of NAFDAC and CODEX. [29]

Peroxide value: The peroxide value of the extracted coconut oils ranged from 0.04 to 1.40 (Table 2), COH had the highest value, followed by COC, while COS had the least peroxide. The peroxide value of the extracted palm kernel oils ranged from 2.55 to 3.00 %. From the peroxide results (Table 1), PKS had the highest value, followed by PKR while PKC

had the least value. All values were below the Codex limit of 10 mEq O_2/kg. [19]

Iodine value: Iodine value is used to determine the amount of unsaturation in oil samples. Vegetable oils can be differentiated by the amount of iodine that they absorbed. [30]

The iodine value range of the coconut oils (3.61 - 7.64 g/100 g), while that of palm kernel oils ranged from 2.55 to 3.00 % (Tables 2 and 3). In the palm the solvent extraction method had the highest value, followed by the roasted extraction while the cold extraction had the least value. All values were below the Codex limit of 10 mEq O_2/kg. [19]

GC-MS Analyses of extracted oils: Comparing the two oils, caprylic acid and stearic acids were present only in PKO, while nonadecenoic acid and eruic acids were present only in coconut oil (Table 4 and 6). Hexadecanoic acid, otherwise called palmitic acid is a known ingredient in cosmetics, soaps and in foods owing to its anticancer, anti-inflammatory and antioxidant properties. Oleic acid, an omega-9 fatty acid which is usually present in most edible oils has many usefulness in the heart, skin and brain, most especially, its role in reducing the quantity of bad fats with a concurrent increase in good fats. In cosmetic industries, it is incorporated into skin care products owing to its ability to enhance skin hydration thus improving skin barrier function. Methyl stearate and stearic acid are also major ingredients in creams and soaps with their attendant emollient and stabilization functions. Linoleic acid's function is equivalent to that of oleic acid in boosting the levels of good fats thus helping the heart retains its integrity. Nonadecenoic acid (nonadecylic acid) has been reported to inhibit cancer cell growth. Erucic acid has ebullient properties, it smooth and moisturizes the skin by improving lipid barrier. It is also reported to have neuroprotective effect through activation of PPAR-delta, a transcription factor involved in neuroprotection. Decanoic acid (capric acid) is used as flavor additive in food industry, and in cosmetic, it is used as an emollient to help stabilize emulsions, and in skincare products, it is used for its moisturizing properties. Supraene (squalene) is a component of sebum (natural oil of the skin) and is valued in cosmetics for its moisturizing, anti-inflammatory, anti-ageing and stress protection abilities [31, 32 33]

CONCLUSION:

This studies clearly demonstrate that extraction methods has a significant impact on some physicochemical properties of oils and fatty acids which could influence their stability and specific industrial uses. In both oils PKO and CO, the percentage recovery, acid value, moisture content, peroxide value and iodine value were significantly affected by the extraction methods. For some other parameters such as relative density, viscosity, refractive index and saponification values, there was no significant effect in the different extraction methods.

The Gas Chromatography-Mass Spectroscopy (GC-MS) analysis showed great impact of extraction methods. In coconut oil CO, a total of 39 phytochemicals were observed, and out of these, COC had 15, COH had 15 while COS had 31. In COC, few phytochemicals dissolved in the cold, but as temperature increased, more compounds were extracted while much more went into solution in the organic solvent COS. Similar results were observed in palm kernel oil PKO with a total of 21 phytochemicals out of which PKS had the highest number 17, while PKC and PKH had 9 each and PKR had 8.

Total of seven fatty acid were observed in each of the oils. In coconut oil out of the 7 fatty acids, four of them; lauric, myristic, palmitic and oleic acids were present in all the extracted oils. However, capric acid was found only in COH, while nonadecylic acid and erucic acid were present only in in COS. Similar trend was observed in PKO. Out of the seven fatty acids, five of them capric, lauric, myristic, palmitic and oleic acids were present in all the extracted oils. Caprylic and stearic acids were present only in PKH and PKS respectively.

Since extraction methods influence the phytoconstituents, the method adopted by any individual or industry should depend on the phytochemical which is of importance in the final product.

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