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EFFECT OF TEMPERATURE ON THE EXTRACTION OF BIOACTIVE COMPONENTS OF PALM KERNEL (*ELAEIS GUINENSIS)* OIL EXTRACTS

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ABSTRACT

Palm kernel (*Elaeis guinensis)* oil (PKO), which is derived from the seeds of the oil palm tree, has been traditionally used in various cultures for its potential health benefits. This study investigated the effects of temperature (High >100°C and low <50°C) on extraction of the bioactive components of Palm Kernel oil extracts. Following the extraction of the hot-pressed palm kernel oil (HPPKO) and cold-pressed palm kernel oil (CPPKO), the physicochemical properties, GC-MS profiling and FTIR analysis of the extracts were carried out. The results showed that HPPKO extract has a significantly $p<0.05$ higher density, acid value, saponification, pH and peroxide value compared with the CPPKO extract. The GC-MS analysis identified twelve bioactive compounds in the HPPKO with 9,12-Octadecadienoic acid methyl ester, (E, E)- as the highest percentage (48.19%) compound, however, only seven bioactive compounds were found in the CPPKO, with 11-Octadecenoic acid, methyl ester having the highest percentage composition (46.45%). The FTIR analysis also revealed the extracts contained compounds with alcohol, carboxylic acids, amines, amides, aromatic compounds, long aliphatic chain, ethers, ketone, aldehyde side chains. In conclusion, the study revealed that both hot-pressed and cold-pressed palm kernel oil extracts contained compounds with potential pharmacological activity for the management of pathological conditions**,** however, the chemical and bioactive properties of these extracts significantly depend on their extraction temperature.

Keywords: Extraction Temperature, GC-MS profiling, FTIR analysis, Palm Kernel oil extracts

INTRODUCTION

Natural oils (Olive oil, Coconut oil. Avocado oil, Fish oil, Flaxseed oil, Palm oil, Palm kernel oil) which are derived from plants, seeds, and nuts have long been valued for their medicinal properties, particularly in managing inflammation. These oils contain bioactive compounds,such as fatty acids, phenolic compounds, and vitamins, which exert anti-inflammatory effects by modulating the production of inflammatory mediators, inhibiting inflammatory pathways, and promoting antioxidant activity (Bensouilah *et al.* 2020). Olive oil, is renowned for its anti-inflammatory effects, primarily attributed to its high content of monounsaturated fats (Calder ***et al.*** 2015). While coconut oil, contains a high concentration of medium- chain fatty acids (MCFAs), primarily lauric acid, with anti- inflammatory properties (Mancini and Mazzocchi**,** 2019). Fish oil, is rich in omega-3 polyunsaturated fatty acids (PUFAs), particularly eicosatetraenoic and (EPA) and docosahexaenoic acid (DHA), has been extensively studied for its potent anti-inflammatory effects (Calder**,** 2013). Flaxseed oil is a rich plant-based source of alpha-linoleic acid (ALA), an omega-3 fatty acid that exhibits anti-inflammatory effects, by reducing the production of pro-inflammatory eicosanoids and promoting the synthesis of anti- inflammatory resolving and protectins (Schneider and Reddy, 2013). Avocado oil is a rich source of monounsaturated fats, particularly oleic acid, as well as various bioactive compounds like phytosterols and tocopherols, which contribute to its anti-inflammatory effects (Valladolid-Acebes, and de la Torre, 2015).

Palm kernel oil (PKO) is extracted from the kernel (seed) of the oil palm fruit (*Elaeis guineensis*), after the removal of the major oil, which is palm oil from the mesocarp of the palm fruit. These two oils are different in terms of preparation and chemical composition (Mba *et al*. 2015) Palm kernel oil is widely used in food processing, cosmetics, and industrial applications due to its unique chemical composition and properties. It is a versatile oil that provides a rich source of medium-chain fatty acids and exhibits a number of functional benefits, including stability at high temperatures and extended shelf life (Bachok *et al.* (2017). Palm kernel oil has a distinct fatty acid composition that differentiates it from other vegetable oils. Its primary components include saturated and unsaturated fatty acids, along with smaller amounts of vitamins and other minor compounds (Sambanthamurthi, *et al.* (2000) It possesses antioxidant and anti-inflammatory properties, antimicrobial, antifungal, and antiviral properties making it a candidate for therapeutic applications. Studies suggest that extracts from palm kernel oil may modulate inflammatory pathways and could provide relief for conditions characterized by excessive inflammation, such as rhinitis (Adeniyi *et al.* 2016*).* Other studies suggest that the mechanisms of action of palm kernel oil extracts may involve the reduction of oxidative stress, modulation of inflammatory pathways and enhancement of the expression of anti-inflammatory mediators, thereby promoting resolution of inflammation (Adeniyi *et al.* 2016; Ebong *et al*. 2020). Traditionally different extraction methods are being employed by Local folks for the production of palm kernel oil, this study aimed to determine the effects of different extraction temperature on the phytochemicals and bioactive

components of palm kernel oil using characterization techniques such as Fourier-transform infrared spectroscopy (FTIR) and gas chromatography-mass spectrometry (GC-MS)

MATERIALS AND METHODS

Plant Collection

The palm kernels seeds were harvested from a farm at Ibaji, Idah local government area of Kogi State, Nigeria. The seeds were identified and authenticated by Mr Akanni a Botanist at the Department of Botany, Federal University Lokoja, Kogi State, Nigeria, and given a voucher number, *Elaies guineensis* (FULH0229). The plant was deposited at the University's Herbarium.

Preparation of Palm Kernel Oil

The hot-pressed palm kernel oil (HPPKO) was produced using the hot extraction method, which involved heating the palm kernels at a temperature above 100°C for 2-3 hours to extract the oil. The Cold pressed palm kernel oil CPPKO was produced using the cold extraction method. This involves extracting oil from the palm kernels with the application of low heat by applying mechanical pressure under low 50°C temperature.

Determination of the Physicochemical Properties of the Oils

The physicochemical properties of the oils were determined as described by Tsado *et al*. (2018))

Determination of Peroxide Value

From the oil sample, 1.00 g of the oil, 1.00 g of potassium iodide and 20cm^3 of solvent mixture (glacial acetic acid/chloroform, 3/2 b y volume) was added into a 250 cm^3 Erlenmeyer flask and the mixture was heated and allowedto boil for one minute. The hot solution was then poured into a flask containing 20 cm^3 of 5% potassium iodide. Thereafter, 3 drops of starch solution were added to the mixture and titrated with 0.025N standardized sodium thiosulphate.

Peroxide value = $\frac{S \times N \times 100}{W}$

where, S = vol. in cm^3 of $Na_2S_2O_3$, N = normality of $Na_2S_2O_3$ and W = weight of oil sample(g).

Determination of Acid Value

A mixture of 2.00g of the oil sample and 5mls of chloroform was measured into a conical flask. Afterwards a mixture of 25mls diethyl ether and ethanol 1:1 (v/v) was also added. Few drops of phenolphthalein was used as the indicator and the mixture was then titrated against 0.1M KOH. The appearance of a pink color that lasted for 30 seconds was noted as an indication of the end point. The acid value was calculated using

where S = vol. in cm^3 of sample, B = vol. in cm^3 of blank and N = Normality of KOH

Acid value = $\frac{S - B \times KOH \times 56.1}{S}$

Determination of Saponification Value

A very little (2.00g) sample of the oil wasweighed into a conical flask and dissolved with 5 cm^3 of chloroform, after which 25 cm^3 of 0.5M alcoholic KOH was added. The mixture was refluxed for 30 minutes and thentransferred into a conical flask, few drops of phenolphthalein indicator used as an indicatorwas added to the reaction and titrated against 0.5M HCl until the pink color disappearsindicating the end point. The saponification value was calculated using:

Saponification value = $\frac{(b-a) \times M \times 56.1}{W}$ X 100

where a = sample titer value, b = blank titer value, M = molarity of the HCl and 56.1 =molecular weight of KOH.

Determination of Iodine Value

Very little (0.30g) oil sample was dissolved in 10mls of chloroform using a 100cm3 glass stoppered flask, followed by the addition of 25mls of Wijj'ssolution. The flask was placed in the dark for 30 minutes after which, 20 cm$_3$ of 10% KI was added and the mixture titrated against 0.1M sodium thiosulphate using few drops of starch as indicator. A blank titration was also carried out. The iodine value was calculated using;

where a = sample titer value, b = blank titer value and W = Weight of sample used (g) (Tsado *et al*. 2018).

Iodine value = $\frac{(b-a) \times M \times 1.269}{W}$ X 100

Determination of Specific Gravity

Density bottle was used for the determination of the specific gravity of the oil. A clean and dry stoppered bottle of 25cm3 capacity was weighedas (W0) and then filled with the oil, stoppered and reweighed as (W1). The oil was then replaced with distilled water after washing and drying the bottle and weighed to give (W2). The specific gravity was then calculated as;

where W0 = weight of dry empty density bottle; W1 = weight of density bottle + oil; W2 = weight of density bottle + distilled water (Tsado *et al*. 2018)

specific gravity = $\frac{W1 - W2}{W2 - W0}$

pH of Oils

2.30g dispersion of the oil was placed in 15cm3 hot water and the pH was determined (after cooling to 300C in a water bath) with the aid of a glass electrode pH

Gas Chromatography-Mass Spectroscopy Analysis of the Hot-pressed Palm Kernel oil (HPPKO) and Cold-Pressed Palm Kernel Oil (CPPKO)

The hot-pressed palm kernel oil (HPPKO) and cold-pressed palm kernel oil (CPPKO) were analysed using GC-MS MODEL-QP2010 PLUS SHIMADZU, JAPAN described by Magashi, and Abdulmalik, (2017) The GC-MS system consists of A VF-5 MS fused silica capillary column (30m length, 0.25mm diameter, and 0.25µm film thickness). The temperature of the column oven ranged from 80°C to 280°C at 2°C each minute. With an ionization energy of 70 eV (electron volt), the ionization energy method was employed to ionize the sample's constituent parts. One of the detectors was set to 200°C, and the injector was set at 250°C. The fixed carrier gas was 99.9995% pure helium with a flow rate of 1.5 ml min-1 and. At a rate of 3.0 scans/s, the mass range between 40 and 1000 m/z was examined. Using a Hamilton syringe, 1.0µl of the oil samples was injected into the GC MS manually for total ion chromatographic analysis (TIC) in the split injection technique. The total run time for this GC-MS method is 27 minutes. The percentage of each oil extract component was represented as a percentage with peak area normalization. Identification of each constituent was carried out by comparing their MS spectra with the mass spectral database of the national institute of standards and technology (NIST).

Fourier-Transform Infrared Spectroscopy Analysis of the Ethanol, Aqueous, Table Salt and Lime Juice Extracts of Ocimum Gratissimum

Protocol for FTIR spectroscopy was done as reported by Satapute *et al*. (2019) which involves the encapsulation of 10mg of the Ethanol, Aqueous, Table salt and lime water extracts in hundred milligrams (100mg) of potassium bromide (KBr) pellet. This was carried out to prepare the translucent sample discs. The samples (400 to 4000 scan range) were loaded into the FTIR spectroscope, with 4cm− 1 resolution for each fraction. The samples (400 to 4000 scan range) were loaded into the FTIR spectroscope, with 4cm− 1 resolution for each fraction, using Ftir-8400s Fourier Transform Infrared Spectrophotometer SHIMADZU, JAPAN.

Statistical Analysis

Data were analyzed using SPSS package version 26.0 (SPSS Inc., Chicago, IL, USA) computer software. Values are expressed as the mean ± SEM. Results were statistically analyzed by one-way analysis of variance (ANOVA) for differences between means of different groups, with the *P* of equal to 0.05 or less regarded as statistically significant. Student's T-test was used for the analysis of data between the two species of animals.

RESULTS AND DISCUSSION

Table 1: Physicochemical Properties of the Palm Kernel Oil Extracts (HPPKO and CPPKO)

Sample	pH	Density	Acid value	Saponification	Iodine value	Peroxide value
HPPKO	5.4	0.94±0.01[a]	10.78±0.12 [a]	290.34±1.39 [a]	37.68±0.42 [a]	11.47±0.13 [a]
CPPKO	5.2	0.89 ±0.01[b]	6.47±0.26 [b]	195.69±0.66 [b]	51.59±0.77 [b]	6.73±0.01 [b]

CPPKO=cold pressed palm kernel oil, HPPKO =hot pressed palm kernel oil. The results are shown as means ±SE of duplicate samples. The different subscript in the same column indicates statistical difference ($p<0.05$)

As shown in Table 1: The physicochemical properties of the palm kernel oil extracts (HPPKO and CPPKO) are significantly $p< 0.05$ different. With the HPPKO having higher density, acid value, saponification, and peroxide value while the CPPKO has higher iodine value.

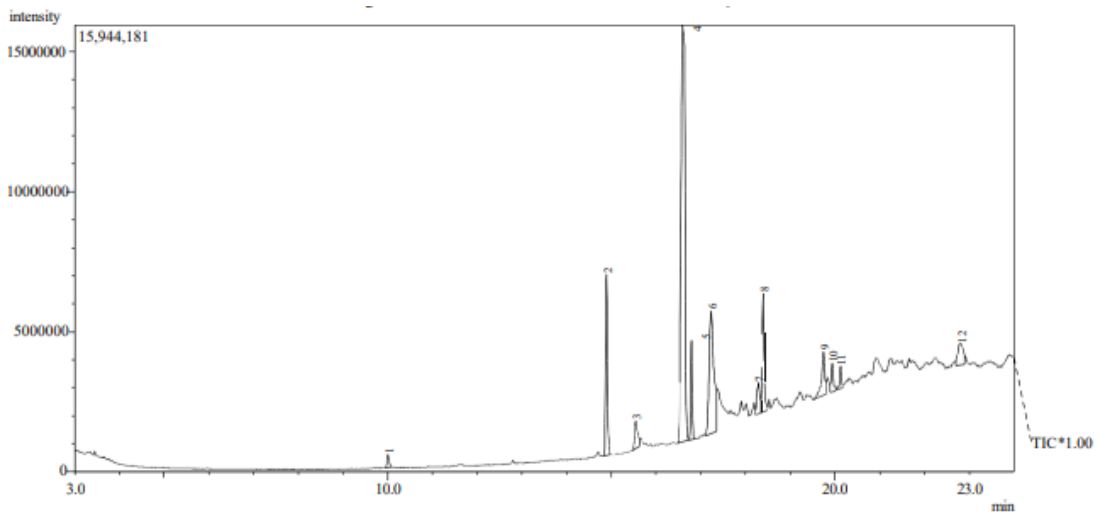

Figure 1: GC-MS Chromatogram of the Hot-pressed Palm Kernel Oil Extract (HPPKO)

The bioactive compounds present in the Hot-pressed palm kernel oil (HPPKO) are shown in the chromatogram Figure 1, indicating the presence of 12 (twelve) bioactive compounds. While the GC-MS profiles such as retention time and relative concentration of these bioactive compounds are presented in Tables 2. The GC-MS analysis reveals the presence of 1-Tridecanol (0.81%), Hexadecanoic acid methyl ester(8.56%), n-Hexadecanoic acid (2.51%), 9,12-Octadecadienoic acid methyl ester, (E,E)-(48.19%), Octadecanoic acid, methyl ester(4.13%), 9,12-Octadecadienoic acid (Z,Z)-(16.11%), 9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-(2.62%), 10-Undecenoic acid, methylester(6.37%), 2-Butyl-3-methyl-5-(2-methylprop-2-enyl) cyclohexanone (4.29%), Methyl 9,10-dihydroxystearate (1.85%), Docosanoic acid, methyl ester(1.24%), Pentacosane (3.32%). The chromatogram detects 9,12-Octadecadienoic acid methyl ester (48.19%) as the main compound.

Table 2: GC-MS Profile of the (HPPKO) Hot Pressed Palm Kernel Oil

Peak	Retention time	Name of the compounds	Peak Area (%)	Molecular formular	Molecular weight	Therapeutic activity
1	10.003	1-Tridecanol	0.81	$C_{13}H_{28}O$	200	Antibacterial, (Togashi *et al*. 2007; Chatterjee 2018)
2	14.889	Hexadecanoic acid, methyl ester	8.56	$C_{17}H_{34}O_2$	270	Antioxidant, Cytotoxic, Antibacterial (Ajanaku et al. 2018; Gupta., 2023; Mostafa *et al*. 2023)
3	15.544	n-Hexadecanoic acid	2.51	$C_{16}H_{32}O_2$	256	Antioxidant, Nematicidal Hypocholesterolemic, , Pesticidal,

Peak	Retention time	Name of the compounds	Peak Area (%)	Molecular formular	Molecular weight	Therapeutic activity
						Lubricant, Antiandrogenic, Flavour (Oni *et al*. 2020; Sakilan *et al.* 2025)
4	16.592	9,12-Octadecadienoic acid methyl ester, (E,E)-	48.19	$C_{19}H_{34}O_2$	294	Antioxidant, Anti-Cancer, and Anti-Inflammatory Properties (Hagr *et al.*, 2018, Souza, 2021)
5	16.789	Octadecanoic acid, methyl ester	4.13	$C_{19}H_{38}O_2$	298	Antiviral, Hypocholesterolemic, Cardioprotective, Antioxidant, (Entigu *et al.* 2013; Shen, 2025)
6	17.229	9,12-Octadecadienoic acid methyl ester (Z,Z)-	16.11	$C_{18}H_{32}O_2$	280	Antiinflammatory, Antiarthritic Hypocholesterolemic, Cancer preventive, Hepatoprotective, Antihistaminic, Antieczemic, and antibacterial (Godwin *et al*. 2015; Souza, 2021; Mensah-Agyei *et al*. 2020)
7	18.289	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	2.62	$C_{19}H_{32}O_2$	292	Anticancer, Antibacterial, Antioxidant, Antipyretic, Cardioprotective, neural function, Antiandrogenic (5-alpha reductase inhibitor), and Antiarthritic properties (Akpuaka, 2013; Godwin *et al*. 2015; Sakilan, 2015)
8	18.392	10-Undecenoic acid, methyl ester	6.37	$C_{12}H_{22}O_2$	198	Antifungal, Cytotoxic, Antioxidant (Nara *et al.* 2017)
9	19.470	2-Butyl-3-methyl-5-(2-methylprop-2-enyl) cyclohexanone	4.29	$C_{15}H_{26}O$	222	No activity reported
10	19.936	Methyl 9,10-dihydroxystearate	1.85	$C_{19}H_{38}O_4$	330	No activity reported
11	20.122	Docosanoic acid, methyl ester	1.24	$C_{23}H_{46}O_2$	354	Anti-inflammatory, anti-aging, cardioprotective, neuroprotective, anti-allergy, prebiotic, cognitive (Li *et al*. 2021; Soni *et al*. 2023)
12	22.815	Pentacosane	3.32	$C_{25}H_{52}$	352	Anti-carcinogenic, Antibacterial (Mishra *et al*. 2019; Roopa *et al*. 2020)

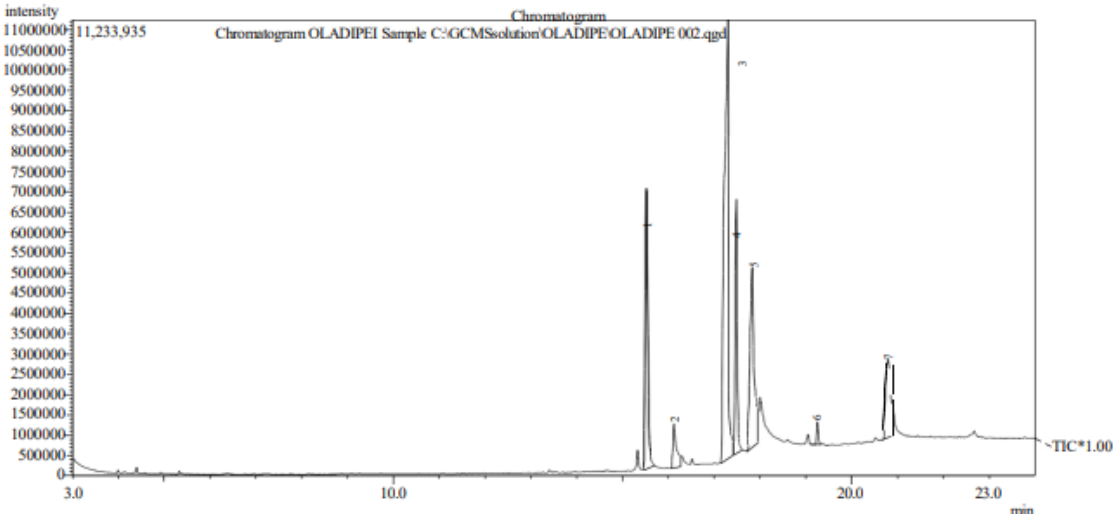

Figure 2: GC-MS Chromatogram of the Cold Pressed Palm Kernel Oil Extract (CPPKO)

The different peaks of the bioactive compounds present in the cold pressed palm kernel oil (CPPKO) are shown in the chromatogram Figure 2. Where the GC-MS profiles of these bioactive compounds are given in Tables 3. The chromatogram indicates a lesser number of compounds compared with the HPPKO, showing 7 peaks representing the presence of seven compounds which include; Pentadecanoic acid, 14-methyl-, methyl ester (13.24%), n-Hexadecanoic acid (3.66%), 11-Octadecenoic acid, methyl ester (46.45%), Octadecanoic acid, methyl ester (10.76%), Oleic Acid (16.80%), Hexadecanoic acid, 15-methyl-, methyl ester (0.84%), Phenol, 3-pentadecyl-(8.04%). With 11-Octadecenoic acid, methyl ester (46.45%) being the highest concentration compound followed by Oleic Acid (16.80%) making up a significant portion of the oil.

Table 3: GC-MS Profile of the Cold Pressed Palm Kernel Oil Extract (CPPKO).

Peak	Retention time	Name of the compounds	Peak Area(%)	Molecular formular	Molecular weight	Therapeutic Activity
1	15.573	Pentadecanoic acid, 14-methyl-,methyl ester	13.24	$C_{17}H_{34}O_2$	270	Antifungal, Antimicrobial (Bashir, 2012)
2	16.123	n-Hexadecanoic acid	3.66	$C_{16}H_{32}O_2$	256	Antioxidant, Hypocholesterolemic Nematicidal, Pesticidal, Lubricant, Antiandrogenic, Flavour (Oni *et al.* 2020; Sakilan *et al.* 2025)
3	17.302	11-Octadecenoic acid, methyl ester	46.45	$C_{19}H_{36}O_2$	296	Antimicrobial, Antioxidant (Alqahtani *et al.* 2019)
4	17.482	Octadecanoic acid, methyl ester	10.76	$C_{19}H_{38}O_2$	298	Antiviral, Hypocholesterolemic, Cardioprotective, Antioxidant, (Entigu et al. 2013; Shen *et al.* 2025)
5	17.854	Oleic Acid	16.80	$C_{18}H_{34}O_2$	282	Anticholesterolemic, Anti-Inflammatory, Antifungal, Antioxidative, and Antibacterial (Hasan *et al*. 2022)
6	19.253	Hexadecanoic acid, 15-methyl-,methyl ester	0.84	$C_{18}H_{36}O_2$	284	Antioxidant; Nematicidal; Pesticidal; Antibacterial; Antifungal; Antiarthritic; Antitumor; Anticancer; Anticoronary; Anti-inflammatory; Hypocholesterolemic; Hepatoprotective (Olivia *et al.* 2021; Gupta *et al.* 2023)
7	20.792	Phenol, 3-pentadecyl-	8.04	$C_{21}H_{36}O$	304	Antibacterial, Fungicidic, Cytotoxic (Cieslik-Boczula and Koll, 2009)

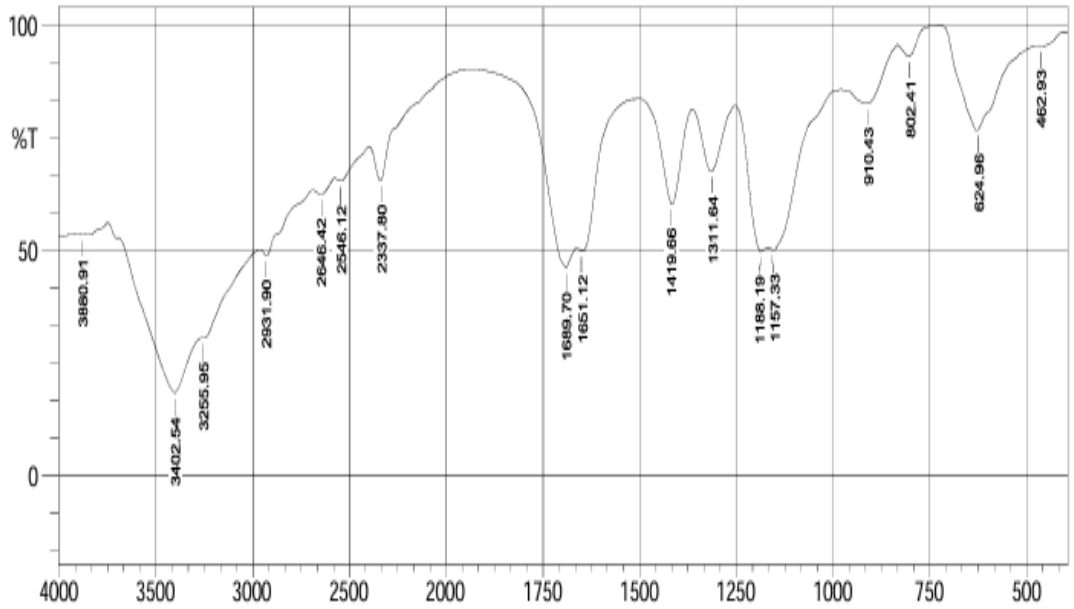

Figure 3: FTIR Spectra of the Hot-Pressed Palm Kernel Oil Extract (HPPKO)

Table 4: FTIR Adsorption Data of Hot-Pressed Palm Kernel Oil Extract (HPPKO)

Wavenumber (cm^{-1})	Functional group	Compound
602.93	C-H bending vibrations	
624.96	C-C stretching vibrations,	aliphatic structures
802.41	C-H bending	Aliphatic

Wavenumber (cm^{-1})	Functional group	Compound
910.43	C-H bending vibrations	Aliphatic
1157.33	C-O stretching vibrations	alcohols or ethers
1188.19	C-O stretching vibrations	esters or carboxylic acids
1311.64	C-O stretching vibrations	esters or carboxylic acids
1419.66	C-H bending vibrations	Methylene (─CH2) of aliphatic
1651.12	C=O stretching vibrations	Carbonyl compound
2337.8	C≡N stretching vibrations	Nitrile
2546.12	C-H stretching vibrations	Methylene of saturated hydrocarbons
2931.9	C-H stretching vibrations	Methylene of saturated hydrocarbons
3402.54	O-H stretching vibrations,	Loosely bonded water molecules
3880.91	N-H stretching vibrations	amines or amides

FTIR adsorption Spectra of Hot-pressed Palm Kernel Oil extract (HPPKO) is shown in figure 3. The numerous peaks shown reveal that the HPPKO fraction contains complex molecules. The peak contains a single bond area 602–1419cm^{-1}, and at 2337-2931cm^{-1}, it reveals a wider absorption band revealing a hydrogen bond in the molecule. A triple bond region (2000–2500cm^{-1}) was detected, implying the presence of C≡C bond in the molecule. Regarding the double bond region (1500–2000cm^{-1}), a sharp bend was observed at 1651cm^{-1} revealing a carbonyl compound. The peak contains a single bond area at 3402cm^{-1} and at 3880cm^{-1}, it reveals a wider absorption band revealing alcohols or carboxylic acids, amines or amides in the molecule respectively.

FTIR adsorption Spectra of cold-pressed Palm Kernel Oil extract (CPPKO) is shown in figure 4. The numerous peaks as shown in Figure 4 revealed that the CPPKO fraction contains numerous peaks. The peak contains a single bond area 493–1404cm^{-1} and reveals the presence of aliphatic groups, alcohols or ethers and esters or carboxylic acids. There is a sharp band at around 2931-3834cm^{-1} revealing the presence of an aliphatic compound (methyl and methylene), carboxylic acids amines or amides. Theres a triple bond region (2000–2500cm^{-1}), implying the presence of C ≡ C bond in the molecule, in this molecule the triple bond region (2337cm^{-1}), revealed the presence of C≡N. Regarding the double bond region (1500–2000cm^{-1}), a narrow peak at about 1643cm^{-1}, reveals a carbonyl compound, which could be an aldehyde.

Aromatic compounds are absent in both fractions since there are no overtone bands at 2000-1650 cm^{-1}.

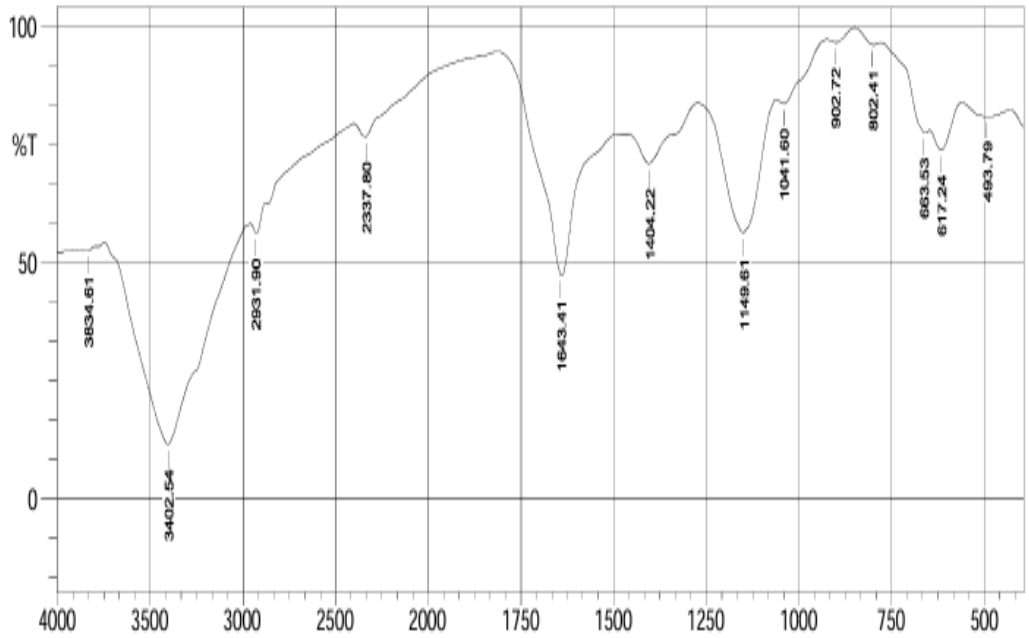

Figure 4: FTIR Spectra of the Cold Pressed Palm Kernel Oil Extract (CPPKO)

Table 5: FTIR Adsorption Data of Cold-Pressed Palm Kernel Oil Extract (CPPKO)

Wavenumber (cm^{-1})	Functional group	Compound
493.79	C-H bending vibrations	aliphatic groups
617.24	C-C stretching vibrations	aliphatic structures
663.53	C-H bending vibrations	
802.41 and 902.72	C-H bending vibrations	Aliphatic
1041.6	C-O stretching vibrations	alcohols or ethers.
1149.61	C-O stretching vibrations	esters or carboxylic acids
1404.22	C-H bending vibrations	Methylene (─CH2) of aliphatic
1643.41	C=O stretching vibrations	Carbonyl

Wavenumber (cm^{-1})	Functional group	Compound
2337.8	C≡N stretching vibrations	Nitrile
2931.9	C-H stretching vibration	Methylene of saturated hydrocarbons
3402.54	O-H stretching vibrations,	Loosely bonded water molecules
3834.61	N-H stretching vibrations	amines or amides.

Discussion

The chemical profile and bioactive properties of Palm Kernel (*Elaeis guinensis)* oil extracts prepared using different extraction temperatures were examined in this study. The results obtained herein suggest that the extraction temperature have a significant effect on the physicochemical properties of the palm kernel oil extracts. There is significant $p<0.05$ differences in the physicochemical properties of the oils (HPPKO and CPPKO), especially in their pH, acid value, saponification, iodine and peroxide value. With the HPPKO having a higher acid, saponification, and peroxide value which signifies it is more oxidized with more free fatty acids. Oils having a higher peroxide and acid values is an indication of a higher degree of lipid peroxidation, which can compromise its stability and freshness Andriani *et al*. (2020). The higher peroxide and saponification values of the HPPKO is an indication of a further processed state due higher temperature of extraction and longer period of extraction. Conversely, the cold-pressed palm kernel extract has lower acid and peroxide values, suggesting it is fresher and contains a higher proportion of unsaturated fatty acids, as supported by its higher iodine value.

The GC-MS chromatogram of the hot-pressed palm kernel oil (HPPKO) as presented in figure 1, showed 12 peaks signifying the presence of 12 (twelve) bioactive compounds as presented in Table 2: with 9,12-Octadecadienoic acid methyl ester (48.19%) as the main compound. While the cold pressed palm kernel oil (CPPKO) as shown in figure 2, showed 7 peaks indicating the presence of 7 (seven) compounds with 11- Octadecenoic acid, methyl ester (46.45%) and Oleic Acid (16.80%) making up a significant portion of the oil. The higher number of compounds found in the HPPKO extracts compared with the CPPKO may be due to the effect of the extraction temperature which significantly affects the number of bioactive compounds released during the extraction, the higher temperature used in the extraction (>100^{o}C) of the HPPKO may have increased the solubility of the bioactive compounds in the oil. Previous studies have suggested that both extraction temperature and solvent type have a significant effect on the general activities and properties of plant extracts and thus increasing extraction temperature for extracts, increased the solubility of the bioactive components at optimum temperature (Onyebuchi and kavas, 2020; Mkhize *et al*. 2023; Usman *et al*. 2024).

Natural oils are sources of many different bioactive components. The chemical composition of the two palm kernel extracts was analyzed to identify the biologically active compounds. The GC-MS profile of the two extracts has indicated the presence of different biologically active compounds that have different pharmacological potentials. One of the identified phytochemicals, n-hexadecenoic acid which was found in both extracts has been reported to possess antioxidant, antibacterial, and antifungal properties (Sakilan *et al.* 2025). It is also used as release agents, in soap production, and cosmetics (Oni *et al.* 2020; Sakilan *et al.* 2025). A low percentage (0.84%) of Hexadecanoic acid, 15-methyl-,methyl ester was also identified as constituent of the CCPKO extract. Studies has shown that this compound possess antioxidant, nematicide, pesticide, antibacterial, antifungal; antiarthritic, antitumor, anticancer, anticoronary, anti-inflammatory, hypocholesterolemic and hepatoprotective properties (Olivia *et al.* 2021; Gupta *et al.* 2023). In addition, the cold extract also contained Oleic acid (16.8%) which possess anticholesterolemic, anti-Inflammatory, antifungal, antioxidative, and antibacterial properties (Hasan *et al*. 2022). Furthermore, phenol, 3-pentadecyl (8.04%) also a component of the CPPKO extract has been reported to have antibacterial, fungicidic, cytotoxic effect (Cieslik-Boczula, 2009), while pentadecanoic acid, 14-methyl-, methyl ester possesses antifungal, and antimicrobial properties (Bashir, 2012). The presence of fatty acids, such as pentadecanoic acid and octadecanoic acid in these extracts, further provides evidence of their hepatoprotective and anti-inflammatory properties, these fatty acids are known to modulate inflammation and liver health; this is in agreement with traditional claims regarding the herb's efficacy in treating liver disorders (Oseni *et al*. 2024)

The hot-pressed palm kernel oil extract contains mainly; 9,12-Octadecadienoic acid methyl ester (E, E), making up around 48.19% of the total composition of the HPPKO, this polyunsaturated fatty acid has been shown to possess antioxidant, anti-Cancer, and anti-Inflammatory Properties (Hagr *et al.*, 2018). High concentrations of polyunsaturated fatty acids are known for their anti-inflammatory and antibacterial properties (Souza *et al*. 2021) which is suggestive of their potential health benefits in respiratory inflammation. For example, 9,12-octadecadienoic acid, methyl ester, (Z, Z)- and 9,12,15 octadecatrienoic acid, methyl ester, (Z, Z, Z)- are polyunsaturated fatty acid methyl esters, which have been found in many plant species including Ageratum conyzoides, *Cannabis sativa* and *Coronopus didymus* (Banaras *et al.* 2021; Javaid *et al*. 2021). As shown in the GC-MS profile, 9,12-Octadecadienoic acid methyl ester (Z, Z)- makes up 16.11% of the HPPKO content. Previous studies have shown that it possesses anti-inflammatory, antiarthritic, hypocholesterolemic, Cancer preventive, hepatoprotective, antihistaminic, antieczemic, and antibacterial properties (Godwin *et al*. 2015; Mensah-Agyei *et al*. 2020; Souza, 2021;). Furthermore, 9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)- which makes up 2.6% of the total component of the HPPKO extract is a polyunsaturated fatty acid which has been reported to possess anticancer, antibacterial, antioxidant, antipyretic, cardioprotective, neural function, antiandrogenic (5-alpha reductase inhibitor), and antiarthritic properties (Akpuaka, 2013; Godwin *et al*. 2015; Sakilan, 2015). Docosanoic acid, methyl ester makes up 1.24% of the total composition of the HPPKO. This fatty acid plays significant role in fetal cognitive development, in addition, it also possesses anti-inflammatory, anti-aging, cardioprotective, neuroprotective, anti-allergy, prebiotic properties (Li *et al.* 2021; Soni *et al*. 2023)

Characterization techniques such as Fourier-transform infrared spectroscopy (FTIR) and Gas chromatography-mass spectrometry (GC-MS) are commonly employed to evaluate the bioactive component of an extract (Nze *et al.* 2025). FTIR helps identify functional groups like hydroxyl, carbonyl, and aromatic rings, while GC-MS provides detailed profiles of the bioactive compounds present in the extracts (Alrefaee *et al*. 2021; Haldhar *et al.* 2021). The FTIR spectra of the

HPPKO and CPPKO are presented in figure 3 and 4 respectively and the adsorption data are shown in Tables 4 and 5. Generally, the spectra depicted several prominent adsorption peaks representing different functional groups present in the samples. The HPPKO fraction contains ethers, amines, amides (due to the presence C=O and N-H), esters, alcohols, carboxylic acids (acid due to the presence of C=O and O-H) while the CPPKO fraction contain ethers, amines, amides, esters, alcohols, carboxylic acids and nitrile (due to the presence of C≡N). Aromatic compounds are absent in both fractions since there are no overtone bands at 2000-1650cm^{-1}.These correlations were made in correspondence to the frequency range and functional group assignment previously reported by Jacob *et al*. (2024).

CONCLUSION

In conclusion, our findings revealed that the bioactive compounds and thus the therapeutic properties of the palm kernel oil extracts (HPPKO and CPPKO) depend on the method of production, extraction and extraction temperature. Hence method of production and extraction temperature are important factors to be considered for bioavailability of nutrients, bioactive components and pharmacological properties of foods, oils and herbs.

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