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Original Research Article

Anti-Inflammatory Effects of Palm Kernel (*Elaeis Guinensis)* Oil Extracts on Histamine-Induced Allergic Rhinitis in Albino Wistar Rats

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ABSTRACT

For centuries plant products such as oils have been used as natural remedies for cold, cough and nasal congestion. The aim of this study was to investigate the anti-inflammatory properties of palm kernel (*Elaeis guinensis)* oil extracts (hot-pressed palm kernel oil (HPPKO) and cold-pressed palm kernel oil (CPPKO)) on histamine-induced (HIS) allergic rhinitis in Albino rats. Rhinitis was induced in the rats after 4 days intraperitoneal (130 mg/kg) histamine sensitization and 7 days intranasal histamine (1%) challenge. The bioactive components of the extracts were profiled using GC-MS and twelve compounds were detected in the HPPKO compared with seven found in the CPPKO. The scoring table for number of sneezes showed that intranasal administration of palm kernel oil extracts inhibited rhinitis as indicated by the decrease in the bouts of sneezes compared to the untreated rats. All the histamine-sensitized/challenged rats had a significant increase ($P<0.05$) in blood hemoglobin (Hb%) level, packed cell volume (PCV%), whiteblood cells count ($WBCx10^9L$), platelets, lymphocytes, as well as a significant ($P<0.05$) decrease in neutrophils and monocytes levels compared with control group. Pre-treatment with CPPKO restored the neutrophils and WBC levels in contrast to HPPKO treated and untreated group ($P<0.05$). Histological examination showed that pretreatment with CPPKO prevented inflammation of the lungs of histamine sensitized/challenged rats. In conclusion, the results showed that pretreatment with cold-pressed palm kernel oils reduced markers of inflammation and symptoms associated with rhinitis in rats, suggesting the efficiency of palm kernel oil extracts as a natural remedy for allergic rhinitis.

Keywords: GC-MS, Hematology, Histamine-induced Rhinitis, Palm kernel oil extracts, Wistar rats.

Introduction

Allergic rhinitis (AR) is a non-communicable inflammatory disease which affects the nasal mucous membrane. It is characterized by sneezing, rhinorrhea, itchy eyes and nasal congestion. The symptoms of AR are induced by the chemical mediator histamine, which is released by mast cells that degranulate, after the recognition of particular antigens by immunoglobulin E (IgE) and its receptor.[1] The etiology of numerous illnesses such as atopic dermatitis (AD), allergic conjunctivitis, pruritus, urticaria, anaphylaxis, and allergic rhinitis (AR, hay fever), and the emergence of their symptoms are significantly influenced by histamine.[2] Thus, to reduce the symptoms of rhinitis, antiallergic medications such antihistamines and release inhibitors of chemical mediators have been employed.[3] These drugs can be classified as mast cell stabilizers, oral corticosteroids, anticholinergic agents, antihistamines, decongestants, mucolytics, and systemic immunotherapy.[4] The administration of antiallergic medications that target mediators generated from mast cells are insufficient in many patients with severe allergic rhinitis, hence a treatment therapy with steroids that have potent anti-inflammatory properties is required.[3]

Derivatives of biomolecules from medicinal plants are emerging as promising alternatives to synthetic medicines.[5] For centuries, plant products such as oils have been used as natural remedies for cold, cough, and nasal congestion in children, because plants contain compounds with antioxidants and antimicrobial properties and are easily degradable in the environment. Palm kernel oils (PKO) are obtained from the seeds of palm tree (*Elaeis guineensis*). Traditionally, the oil is used in culinary applications and contains saturated fatty acids, predominantly lauric acid,[6] as well as unsaturated fatty acids. PKO has attracted attention in medicinal research due to its potential therapeutic effects. Preliminary studies have shown that specific compounds within PKO can suppress the production and release of pro-inflammatory cytokines such as; IL-6, IL-1β, and TNF-α.[7] According to other researches, the mechanism(s) 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.[8; 9] However, there is a paucity of research examining the specific effects of natural

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extracts, such as those from palm kernel oil, on histamine-induced rhinitis. Additionally, the mechanisms by which these extracts exert their anti-inflammatory effects remain poorly understood. This study aimed to induce allergic rhinitis in Wistar rats through intraperitoneal sensitization and intranasal challenge with histamine, to elucidate the effects of palm kernel oil extracts on symptoms of allergic rhinitis.

Materials and Methods

Chemicals

Reagents and chemicals: All the reagents and chemicals used for the following analysis were purchased from Molychem Laboratories in India. Ketamine was purchased from Themis Medicare Ltd in India.

Plant collection and identification

The palm kernels seeds were harvested in April 2024 at a farm in Idah Local Government Area of Kogi State, Nigeria. The ripped palm kernel seeds were verified 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 extracts

The hot-pressed palm kernel oil (HPPKO) was produced using the hot extraction method, which involved heating the palm kernels between 100°C and 120°C for 2-3 hours to extract the oil. The cold-pressed palm kernel oil CPPKO was produced using the cold extraction method. This involved extracting oil from the palm kernels with the application of low heat by applying mechanical pressure at a temperature of less than 50°C.

Analysis of the physicochemical properties of the oils

Physicochemical properties (pH, acid value, density, saponification, iodine, and the peroxide value) of the oils were analysed by the methods described by [10]

Analysis of the Fatty acid content of the palm kernel oil extracts using Gas Chromatography-Mass Spectrometry (GC-MS)

Analysis of the fatty acids components of the palm kernel oil extracts (HPPKO and CPPKO) was carried out, using QP2010 PLUS SHIMADZU, Gas Chromatography-Mass Spectrometer MODEL which was obtained from JAPAN. The GC–MS system was equipped with a VF-5SilMS capillary column (with thickness film: 0.25mm in diameter, 30m in length and 0.25µm thickness) The carrier gas (helium gas, 99.999% purity) flow rate at 1.5 mL/min. The oven temperature of the column was programmed from 80°C to 280°C at 2°C min-1. Ionization of the sample components was performed in electron impact mode (EI, 70 eV). The injector temperature was fixed at 250°C. The mass range from 40-1000 m/z was scanned at a rate of 3.0scans/s. 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).[11]

Experimental Animals

Six weeks old male Albino Wistar rats were obtained from Achievers University, Owo, Ondo State, Nigeria, Animal House. The rats were maintained following standard conditions of 12 hours' light/dark cycles before and during the experiment. The rats were fed with pelletized animal feeds manufactured by Animal Care Limited, Nigeria. The feed and water were given *ad libitum.*

All animal experiments were conducted according to the recommendations provided in the "Guide for the Care and Use of Laboratory Animals. Experimental protocols were approved by the Health Research Committee of the Federal Medical Centre Owo, in Ondo State, Nigeria, with approval number FMCOWO/HREC/2024/106.

Induction of allergic rhinitis, drug treatment and grouping[12]

After two weeks' acclimatization, the rats were randomly divided into five groups (n= 5 animals per group) as follows;

Vehicle only (Rats sensitized and challenged with normal saline)
HIS + vehicle (Rats sensitized and challenged with histamine with no further treatment)
HIS + HPPKO (Rats sensitized and challenged with histamine + treatment with HPPKO)
HIS + CPPKO (Rats sensitized and challenged with histamine + treatment with CPPKO)
HIS + Loratadine (Rats sensitized and challenged with histamine + treatment with loratadine)

The rats in the control group were administered normal saline intraperitoneally. The rats in the other groups were sensitized with an intraperitoneal injection of 4% Histamine (HIS) (previously dissolved in normal saline). On the first day of the experiment, each rat, except for the control group, were given 130 mg/kg of 4% histamine in normal saline intraperitoneally, every other day for four days. Two days after the sensitization, these rats were administered 30µl of 1% HIS solution (dissolved in normal saline) intranasally using a micropipette (each rat was held in place by the observer) for seven consecutive days. The HIS-sensitized/challenged rats were administered the palm kernel extracts (HPPKO and CPPKO) intranasally while the standard drug (loratadine) was administered orally by gavage, 30 minutes before each HIS challenge.[12] After each histamine challenge, the rats were observed for 30 minutes for the development of sneezing, perioral cyanosis, respiratory acceleration, abdominal spasm, and nodding breathing. Rhinitis was established in the rats' model as observed in the symptoms characterized by sneezing, nasal congestion and runny nose (only three rats were placed under observation per group, and each rat was observed individually). The rats were sacrificed 24 hours after the final challenge, using ketamine injection (100 mg/kg intraperitoneally). Blood samples were drawn via heart puncture into EDTA bottles for hematological assay. Thereafter, the lungs of the animals were removed for histological assay.

Hematological Analysis

After the last nasal and oral application of the palm kernel oil extracts and drug, animals were anesthetized by intramuscular injection of ketamine (100mg/kg). Hematological analysis of the blood samples was carried out within 24 hours of sample collection. The hematological parameters (Hb, WBC, PCV, platelets volume, LYM, Neut, Monocyte, Eosinophil and Basophil) were analyzed with Sysmex KX-21N hematology analyzer, according to the manufacturer's instructions.

Histological Assays

The lung tissues isolated from the control group and groups treated with different oil extracts and drugs were examined histologically. The lungs tissues were washed and fixed in 10 % buffered formalin solution for 24 hours. The lung tissues were fixed with 10% neutral buffered formalin, dehydrated with gradient alcohol (100%, 90%, 80%, and 70%), and embedded in molten paraffin wax before sectioning to 5-6 microns, using a rotary microtome. The sections were stained with hematoxylin for 5 minutes and examined using a microscope. The excessive hematoxylin was removed by rinsing the section thoroughly in water, and briefly differentiated with 1% acid alcohol. The nucleic was turned bluish using scott tap water, and rinsed in water followed by a counter-staining with 1% aqueous eosin. The clearing was done with xylene and then mounted with DPX, after which the slides were examined at 10x and 40x magnification under a light microscope. [13]

Statistical Analysis

Data were analyzed using statistical package for social sciences (SPSS) software 26.0 version (SPSS Inc., Chicago, IL, USA). Values are presented as the mean ± SEM. One-way analysis of variance (ANOVA) was used for variances between means of different groups. Values having a P value equal to 0.05 or less is regarded as statistically significant.

Results and Discussion

The palm kernel oil extracts have notable differences, especially in their pH, iodine, acid value, saponification and peroxide value. The HPPKO has a higher acid, saponification and peroxide value, indicating it is more oxidized with more free fatty acids. Findings by [14] highlight how higher peroxide and acid values indicated a degree of lipid peroxidation, which can compromise oil stability and freshness. The HPPKO, with its higher peroxide and saponification values, may indicate a more processed state, which could have influenced the biochemical components of the oils and hence their biological properties. 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. In this study, the different production processes and extraction temperatures used for the oil production significantly affect the physicochemical properties and the bioactive properties of the palm kernel oil extracts (Table 1). Thus, food processing methods, plant extraction methods, or oil extraction temperature are important factors to be considered for the bioavailability of nutrients and pharmacokinetic properties of foods and herbs.

In the last few years, GC-MS has been used to analyze the bioactive constituents of medicinal plants and obtain information on the bioactive compounds with precise accuracy and reliability. Most of these substances are secondary metabolites, of which many have been isolated and estimated.

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. Values having different subscript in the same column are statistically difference at $p<0.05$

Figure 1 presents the GC-MS chromatogram of the hot-pressed palm kernel oil (HPPKO), as displayed by the peaks. Twelve bioactive compounds were identified and presented in Table 2. The results reveal 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%),9,12-Octadecadienoic acid (Z, Z)-(16.11%), 9,12,15-Octadecatrienoic acid, Octadecanoic acid, methyl ester(4.13%), methyl ester, (Z, Z, Z)-(2.62%), 10-Undecenoic acid, methyl ester(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%).

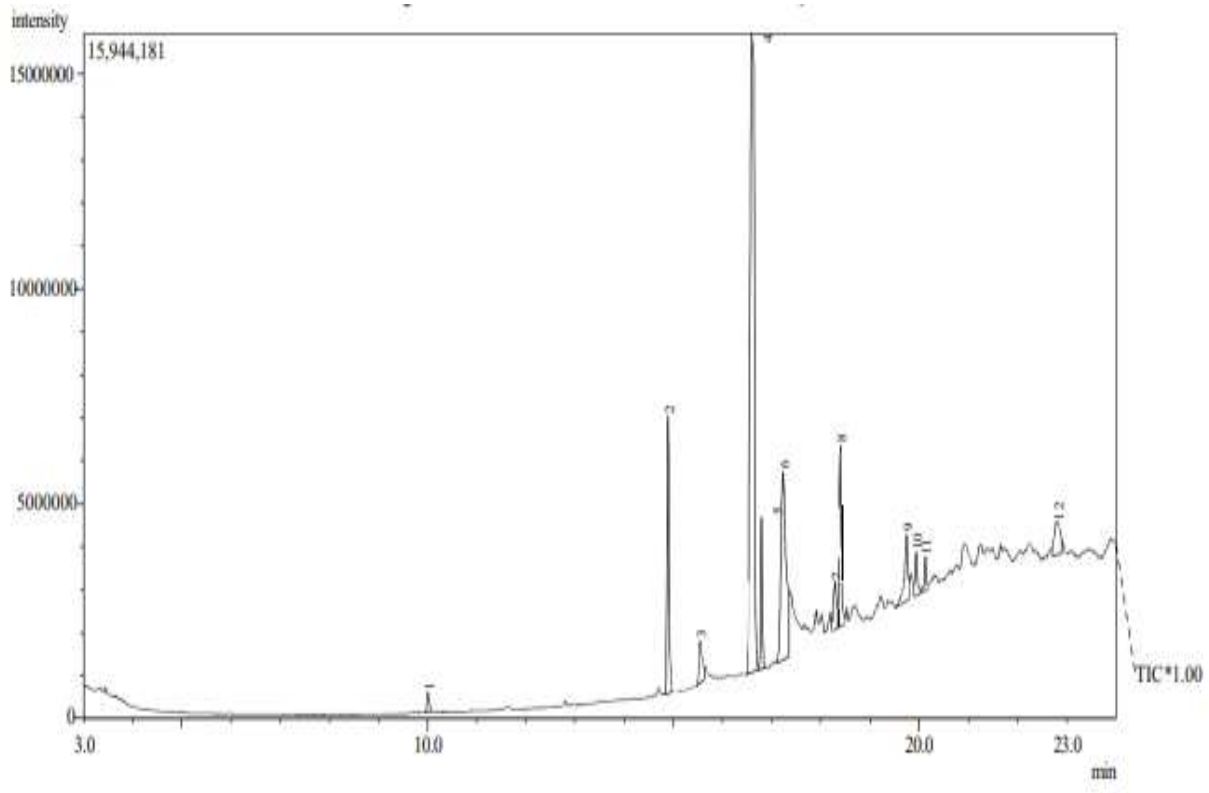

Figure 1: GC-MS Chromatogram of the Hot-pressed Palm Kernel Oil Extract (HPPKO)

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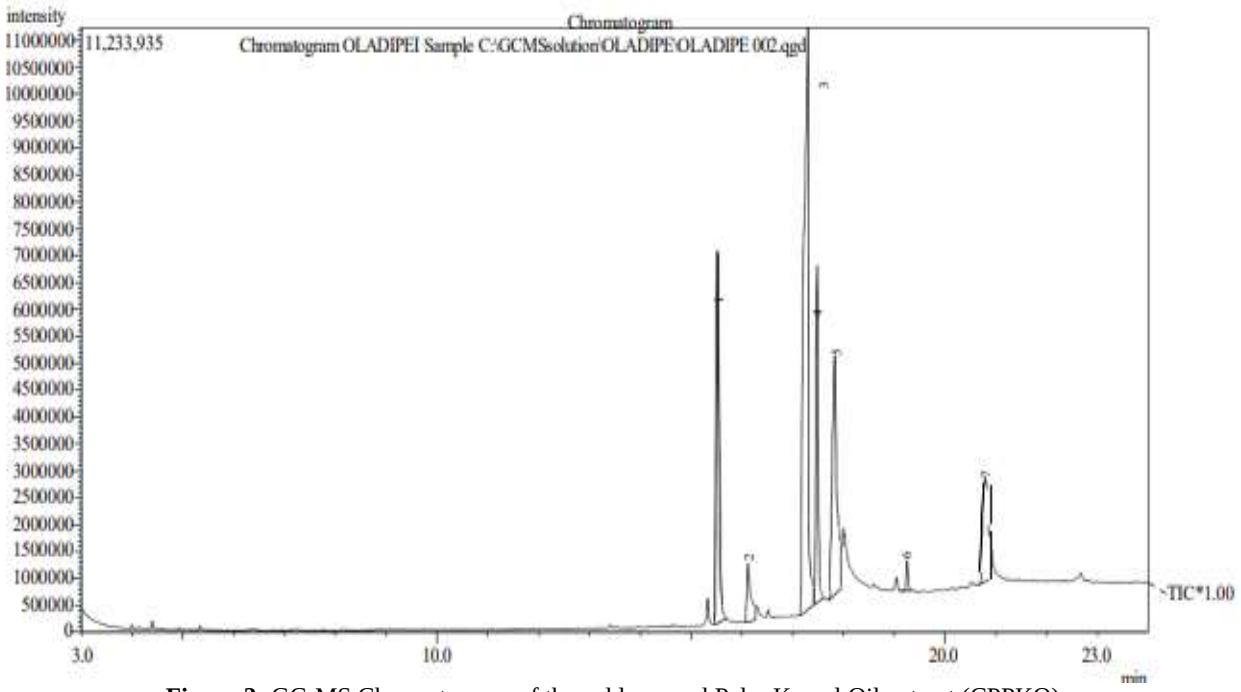
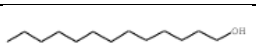
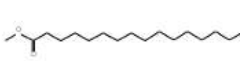
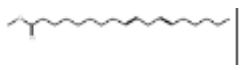
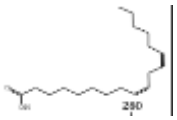


Figure 2: GC-MS Chromatogram of the cold-pressed Palm Kernel Oil extract (CPPKO)

The chromatogram detects 9,12-Octadecadienoic acid methyl ester (48.19%) as the major compound. While GC-MS chromatogram of the cold-pressed palm kernel oil (CPPKO) as shown in Figure 2 showed 7 peaks signifying the presence of 7 (seven) compounds which include: Pentadecanoic acid, 14-methyl-, methyl ester (13.24%), n-Hexadecanoic acid (3.66%), 11-Octadecenoic acid, methyl ester (46.45%), 15-methyl-, methyl ester (0.84%), Phenol, 3-pentadecyl- (8.04%) Octadecanoic acid, methyl ester (10.76%), Oleic Acid (16.80%), Hexadecanoic acid, 11- Octadecenoic acid, methyl ester (46.45%) and Oleic Acid (16.80%) make up a significant portion of the oil. One of the identified phytochemicals, n-hexadecenoic acid, which was identified in both extracts, has been reported in an earlier study to possess antibacterial, antioxidant, and antifungal properties.[15] Hexadecenoic acid which is found mostly in animals, plants or microorganisms as a form of saturated fatty acid, and is used as a release agent in cosmetics and soap production.[16]

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

Peak	Retention time	Name of the compounds	Peak Area (%)	Molecular formula	Molecular weight	Structure
1	10.003	1-Tridecanol	0.81	$C_{13}H_{28}O$	200	
2	14.889	Hexadecanoic acid, methyl ester	8.56	$C_{17}H_{34}O_2$	270	
3	15.544	n-Hexadecanoic acid	2.51	$C_{16}H_{32}O_2$	256	
4	16.592	9,12-Octadecadienoic acid methyl ester, (E, E)-	48.19	$C_{19}H_{34}O_2$	294	
5	16.789	Octadecanoic acid, methyl ester	4.13	$C_{19}H_{38}O_2$	298	
6	17.229	9,12-Octadecadienoic acid (Z,Z)-	16.11	$C_{18}H_{32}O_2$	280	

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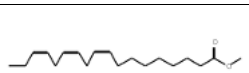
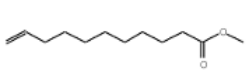
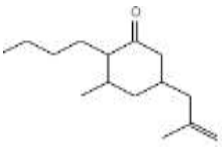
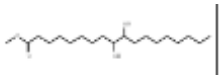
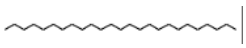
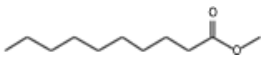
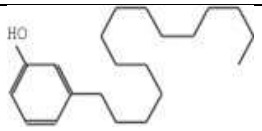
7	18.289	9,12,15-Octadecatrienoic acid, methyl ester, (Z, Z, Z)-	2.62	$C_{19}H_{32}O_2$	292	
8	18.392	10-Undecenoic acid, methyl ester	6.37	$C_{12}H_{22}O_2$	198	
9	19.470	2-Butyl-3-methyl-5-(2-methylprop-2-enyl) cyclohexanone	4.29	$C_{15}H_{26}O$	222	
10	19.936	Methyl 9,10-dihydroxystearate	1.85	$C_{19}H_{38}O_4$	330	
11	20.122	Docosanoic acid, methyl ester	1.24	$C_{23}H_{46}O_2$	354	
12	22.815	Pentacosane	3.32	$C_{25}H_{52}$	352	

The notable variations in the number and components of the bioactive compounds found in the hot and cold-pressed palm kernel extracts may result from the different extraction methods used. The findings showed that the extraction temperature had an effect on the fatty acid components of the extracts (Table 3). The hot extract contains mainly 9,12-Octadecadienoic acid methyl ester (E, E), making up around 48.19% of the total composition, as well as other polyunsaturated fatty acids. High concentration of these polyunsaturated fatty acids are known for their antibacterial as well as anti-inflammatory properties as documented by [17] and could suggest potential health benefits in respiratory inflammation. Meanwhile, the cold extract contained a lower proportion of polyunsaturated fatty acids but a higher concentration of Oleic acid (16.8%) and Phenol, 3-pentadecyl (8.04%), which have both been demonstrated to have moderate anti-inflammatory effects.[18] In addition, Oleic acid and tripalmitin also possess anticholesterolemic, anti-inflammatory, antifungal, antioxidative, and antibacterial properties.[16]

Table 3: GC-MS profile of the cold-pressed palm kernel oil Extract (CPPKO)

Peak	Retention time	Name of the compounds	Peak Area (%)	Molecular formula	Molecular weight	Chemical structure
1	15.573	Pentadecanoic acid, 14-methyl-,methyl ester	13.24	$C_{17}H_{34}O_2$	270	
2	16.123	n-Hexadecanoic acid	3.66	$C_{16}H_{32}O_2$	256	
3	17.302	11-Octadecenoic acid, methyl ester	46.45	$C_{19}H_{36}O_2$	296	
4	17.482	Octadecanoic acid, methyl ester	10.76	$CC_{19}H_{38}O_2$	298	
5	17.854	Oleic Acid	16.80	$C_{18}H_{34}O_2$	282	
6	19.253	Hexadecanoic acid, 15-methyl-,methyl ester	0.84	$C_{18}H_{36}O_2$	284	

7	20.792	Phenol,3-pentadecyl-	8.04	$C_{21}H_{36}O$	304	

Allergic inflammation can be induced in various organs (with high mast cell densities) of an antigen-sensitized mouse. These organs include the skin, eyes, lungs, and gastrointestinal tract. [19] Hence, models for allergic rhinitis, with pathophysiological responses reflecting nasal hyperresponsiveness (NHR,) can be generated in antigen-sensitized and -challenged rats using several experimental nasal symptom inducers such as histamine,[12] ovalbumin, [20; 21] and cedar pollen.[12] In this study, rhinitis was established in the rats as observed in the symptoms which include runny nose, sneezing, and nasal congestion after 4 days of intraperitoneal Histamine sensitization and subsequent 7 days of intranasal histamine challenge (Table 4). The symptoms were observed 30 minutes after the direct application of histamine to the nasal canal using a micropipette. A previous study by [22] reported that nose rubs and sneezing increased in a repeatable, dose-dependent manner after a nasal histamine challenge. However, our data on bouts of sneezes showed that repeated intranasal antigen (Histamine) challenge reduced sensitivity to the antigen at the nasal mucosa. Unlike in humans, for example, specific antigens, IgE increases during pollen season, but decreases without further antigen exposure.[23] In this study, our rhinitis model's response to intranasal histamine challenge decreased gradually to a steady state, indicating reduced sensitivity to histamine exposure. This finding is consistent with an earlier animal study by [12] which reported a gradual decrease in NHR to a steady state after a short-term exposure to antigen sensitization in mice. Although the sneezing score of the HIS-sensitized/challenged untreated group revealed that the NHR symptoms decrease in measured response from Day 1 to Day 7 possibly due to natural recovery or reduced sensitivity to histamine exposure. However, the scores remain higher than those of the other groups, indicating prolonged effects of histamine without intervention. Data from the Hot-pressed palm kernel (HPPKO) oil-treated group, compared with other treated groups, showed a gradual decrease in the NHR symptoms from day 3, indicating the modulating effects of the oil extract on histamine response compared to the histamine-challenged untreated rat models. However, pre-treatment with the cold-pressed palm kernel oil (CPPKO) produced an immediate and steady reduction in the rat's response to histamine challenge compared to HPPKO. This suggests that cold-pressed palm kernel oil may be faster than hot-pressed palm kernel oil in modulating the NHR symptoms associated with Histamine-induced allergic rhinitis in rats.

Table 4: Effect of Palm Kernel Oil Extracts (HPPKO and CPPKO) and Loratadine on Sneezing and Nasal Rubbing in Histamine-induced rhinitis in Wistar rats

Groups/	Number of days						
Treatments	1	2	3	4	5	6	7
Control	unobserved	unobserved	unobserved	unobserved	unobserved	unobserved	unobserved
HIS	10.66±5.36	7.00±1.73	5.66±2.72	3.33±0.33	6.20±0.52	5.20±0.37	4.00±1.51
HIS+HPPKO	9.00±2.65	6.00±0.58	7.33±1.76	6.00±1.00	5.20±0.97	4.50±1.25	3.20±0.58
HIS+CPPKO	7.00±1.15	7.00±0.58	6.00±1.73	5.00±1.52	5.00±1.00	3.80±0.86	3.00±0.63
HIS+ Loratadine	1.00±0.00	5.67±0.33	4.00±0.00	3.33±0.33	4.80±0.73	4.00±0.32	3.40±0.40

Some of the primary roles of histamine is vasodilation, vascular permeability, hypoxia, as well as vascular edema. Histamine is also involved in the pro-inflammatory activities which influence the adaptive immune system via the recruitment, maturation, and activation of immune effector cells. It also plays a role in the innate immune system by interacting with natural killer cells, dendritic cells and granulocytes.[24] As shown in Tables 5 and 6, four days' intraperitoneal sensitization (immunization) with histamine followed by seven days' intranasal histamine challenge in rats, significantly $p<0.05$ increased the WBC, %Hb, PCV, Platelet count and Lymphocytes levels in all the histamine induced rats compared with the healthy control rats. This signifies an active pro-inflammatory and immune-mediated effects of histamine on these cells. An increase in the circulating level of WBC and lymphocytes is an indication of increased sensitization by an allergen or antigen. [25] The rhinitis model groups had a significantly $p< 0.05$ higher WBC level compared with the normal control group. However, treatment with CPPKO and loratadine significantly reduced the WBC level compared with the untreated and HPPKO-treated group. Although there is no direct relationship between allergies, hemoglobin, and PCV levels, an increase in circulating WBC levels is associated with exposure to allergies, which may subsequently affect the PCV and hemoglobin levels. Allergies (such as allergic asthma, allergic rhinitis, allergic contact dermatitis, atopic dermatitis, and food allergies) are triggered by abnormal immune response which can spur systemic (whole-body) inflammation resulting in an increased platelet count.[26] As shown in the results, histamine sensitization/challenge significantly increased the platelet level in all the rhinitis model groups $p<0.05$. This increased platelet count may have resulted from the systemic response to the histamine sensitization and challenge.

Conversely, histamine challenge caused a significant $p<0.05$ decrease in the circulating levels of monocytes and neutrophils in the challenged groups, especially the HPPKO treated and untreated group compared with the control. This may have resulted from reduced recruitment of both neutrophils and monocytes to the site of inflammation due to overstimulation of the histamine receptor HR4 by the histamine challenge. A previous study by [27] revealed that stimulation of histamine receptor HR4 on human monocytes leads to a $Ca2+$ influx and an inhibition of the CCL2 (a specific chemokine that attracts monocytes and neutrophils) production, resulting in the declination of monocyte recruitment.

Table 5: Effect of Palm Kernel Oil Extracts (HPPKO and CPPKO) and Loratadine on hematological parameters in Histamine-induced rhinitis in Rats

Groups/ Treatment	(Hb) g/dl	%(PCV)	Platelet $\times 10^9$/L	(TWBC) $\times 10^9$/L
1. Control	10.80 ± 0.66^{bcde}	34.47 ± 1.19^{bcde}	189.33 ± 8.95^{cde}	2.62 ± 0.48^{c}
2. HIS	14.32 ± 1.27^{ac}	46.70 ± 2.55	544.00 ± 169.64^{c}	4.33 ± 0.28
3.HIS+ HPPKO	17.62 ± 0.54^{ab}	48.50 ± 1.35	927.00 ± 14.29	6.04 ± 1.29^{ade}
4.HIS+CPPKO	16.14 ± 0.73^{a}	44.93 ± 1.29	718.00 ± 101.99	3.80 ± 0.58^{c}
5.HIS+ Loratadine	15.47 ± 1.73^{a}	48.63 ± 1.80	772.00 ± 59.94	3.18 ± 0.59^{c}

Data are presented as means ±SE (n=5). Values having different subscript in the same column are statistically difference at $p<0.05$.

Table 6: Effect of Palm Kernel Oil Extracts (HPPKO and CPPKO) and loratadine on hematological parameters of Histamine-Induced Rhinitis Albino Rat

Groups	Neu%	Lym%	Mon%	Eos%	Bas%
1. Control	25.60 ± 2.63^{bc}	67.15 ± 2.96^{b}	8.50 ± 0.29^{bcde}	1.08 ± 0.33	2.57 ± 0.92
2. HIS	8.42 ± 1.79^{ad}	89.37 ± 2.33^{a}	1.40 ± 0.00	0.85 ± 0.36	1.84 ± 0.59
3.HIS+HHPKO	9.60 ± 2.70^{a}	80.73 ± 7.42	2.83 ± 1.28	0.13 ± 0.95	1.37 ± 0.89
4.HIS+CPPKO	21.65 ± 4.49^{b}	76.24 ± 6.07	1.35 ± 1.22	1.18 ± 0.42	1.14 ± 0.63
5. HIS +Loratadine	17.10 ± 5.66	78.65 ± 5.49	1.29 ± 0.95	0.90 ± 0.58	2.10 ± 0.77

Data are presented as means ±SE (n=5). Values having different subscript in the same column are statistically difference at $p<0.05$.

In this study, pretreatment with HPPKO resulted in a higher circulating level of the WBC, platelet, Hb and PCV compared with loratadine and the CPPKO-treated group. This may be due to its pro-inflammatory properties. As shown in the data obtained, pretreatment with the HPPKO did not inhibit the effect of histamine on the rats, but rather stimulated the immune system and promoted a pro-inflammatory environment as well. Although the mechanism of action of the HPPKO on the histamine receptor is not yet clarified. Conversely, pre-treatment with CPPKO extract significantly reduced the inflammatory effects of Histamine on the rats compared with HPPKO, but this reduction is not completely.

The Histopathological analysis revealed that histamine sensitization/challenge caused a significant lung inflammation and hemorrhage in the untreated group, which is indicative of severe pneumonitis. Pretreatment with the HPPKO did not completely prevent pneumonitis, as shown in the infiltration of alveoli and interstitium by inflammatory cell infiltrates (mild pneumonitis), indicating that the hot-pressed palm kernel extract could only partially mitigate the inflammatory effects of histamine on the lungs of the rhinitis rat models (Figure 3). In contrast, cold-pressed palm kernel oil-treated rats displayed no significant lung abnormalities, suggesting that the cold extract had better protective effects against histamine-induced lung damage in rats.

The findings of our investigation are consistent with preceding studies on the anti-inflammatory properties of palm kernel oil, although the distinction between hot and cold extraction methods is rarely addressed in the literature. Studies have demonstrated that palm kernel oil contains bioactive compounds with antioxidant and anti-inflammatory effects, which are often attributed to its fatty acid compositions, particularly lauric acid and oleic acid. [28] However, the overall pro-inflammatory response seen in the hematological data of the hot-pressed palm kernel extract could be attributed to the increased oxidation of products. Oleic acid is known to have anti-inflammatory properties, which may explain the better outcomes seen with CPPKO in terms of histamine modulation and lung protection. This is in accordance with an earlier study, which reported that cold-extracted oils tend to retain more bioactive compounds,[28] which may account for the protective effect against histamine-induced rhinitis.

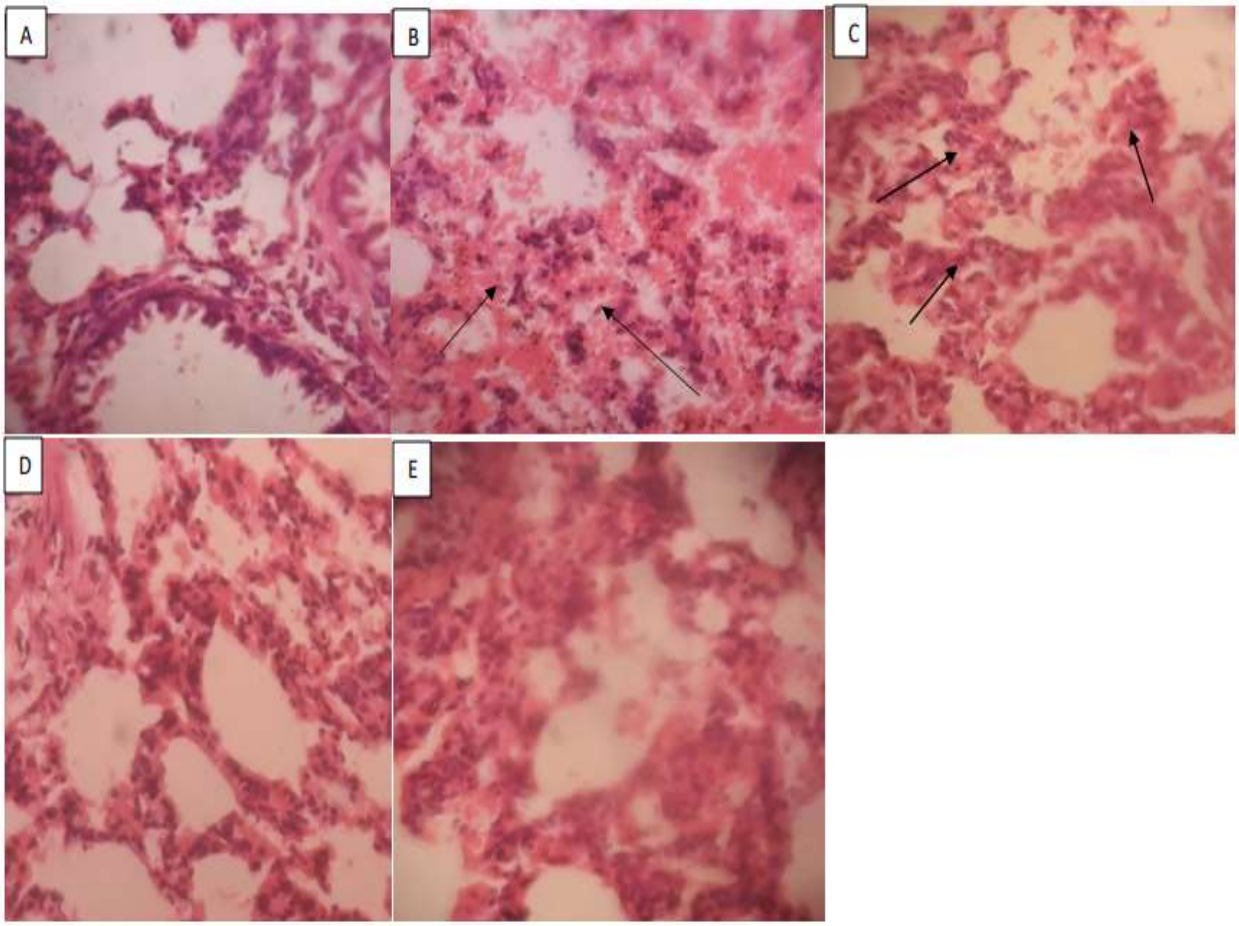


Figure 3: Photomicrograph showing the lung sections of; A=Control rats sensitized/challenged with normal saline showing normal alveoli spaces, B= rats sensitized/challenged with histamine, showing inflammation of the lung suggestive of severe pneumonitis. C= rats sensitized/challenged with histamine and treated with HPPKO showing infiltration of the septa of alveoli and interstitium (moderate pneumonitis) D= rats sensitized/challenged with histamine and treated with CPPKO showing no signs of inflammation and E= rats sensitized/challenged with histamine and treated with loratadine showing normal alveoli spaces.

Conclusion

In conclusion, this study revealed the differential effects of hot-pressed and cold-pressed extracts of palm kernel oils on histamine-induced allergic rhinitis in rats. The distinct chemical profiles of HPPKO and CPPKO suggest that cold-pressed extraction may preserve more beneficial unsaturated fatty acids, resulting in better modulation of histamine responses and protection against lung damage. The hot-pressed palm kernel extract, conversely possesses a pro-inflammatory potential owing to the higher content of oxidation products and free fatty acids. These results suggest that cold-extracted palm kernel oil has potential therapeutic benefits for managing histamine-induced allergic reactions and inflammation, offering a more natural alternative to synthetic antihistamines. Moreover, the study emphasizes the importance of the extraction process in the determination of the biological activity of natural oils, which could have broader implications for the formulation of nutraceuticals derived from palm kernel oil.

Conflict of interest

The authors declare no conflicts of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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