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Physicochemical Properties of Mango, Coconut and Cotton Seed Oils and their Ameliorating Effect on Renal Toxicity in Wistar Rats

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Abstract

Nephrotoxicity is the rapid deterioration in kidney function due to the toxic effect of medications and chemicals. Mango, coconut and cotton seed oils are natural plant oils with various beneficial and therapeutic effect. This study was designed to investigate the potential ameliorating effect of mango kernel, coconut, and cottonseed oils on hydrogen peroxide-induced renal toxicity. The physicochemical properties of the oils were determined, and kidney markers of the blood serum, such as urea and creatine, were analysed, followed by histopathology of the kidney. The physicochemical properties showed that the oil yield was 12.06 %, 65.29 %, and 35.18 % for mango, coconut, and cottonseed oils, respectively. Mango kernel oil had a higher melting point (29.25). The specific gravity of mango kernel oil, coconut oil, and cotton seed oils was 0.89, 0.91, and 0.88, respectively. The highest flash point was recorded in cottonseed oil (302.45). Cotton seed oil had the highest moisture content (0.35). The pH of Mango kernel oil was 4.88, coconut oil 6.97 and cotton seed oil 6.15. Mango kernel oil had the highest smoke point (250.73). The lowest peroxide value was observed in coconut oil (0.52), while the highest was in cottonseed oil (3.43). Cotton seed oil had the highest acid value (6.82) and iodine value (42.16). The saponification values of mango kernel, coconut, and cottonseed oils were 142.39, 258.98, and 180.31, respectively. The unsaponifiable matter was 1.46 in mango oil, 0.42 in coconut oil, and 1.50 in cottonseed oil. The percentage of free fatty acids in mango kernel oil, coconut oil, and cottonseed oil was 2.14, 0.21, and 3.40, respectively. The levels of creatinine and urea were significantly reduced in the serum of rats that received the oils, as compared to the positive control group. The histopathological examination showed significant recovery in the group treated with coconut oil. The results of this study, however, established that coconut oil had a better ameliorating effect on kidney toxicity compared to the other oils under study, which may be due to its antioxidant properties.

Keywords: Coconut, Cotton, Mango, Oil, Physicochemical, Renal

INTRODUCTION

Plant-derived oils are crucial not only as dietary components but also for their potential health benefits, including anti-inflammatory and antioxidant properties that may mitigate organ toxicity. Studies suggest that oils such as those from mango, coconut, and cottonseed are rich in the fat-soluble vitamins A, D, E, and K, which have antioxidant and therapeutic properties (Zhou *et al.*, 2020), bioactive compounds, including omega 3 and omega 6 fatty acids, phytochemicals and polyphenols, which could offer protective effects against renal damage caused by oxidative stress. Nephrotoxicity, often triggered by oxidative agents like hydrogen peroxide (H_2O_2), leads to kidney dysfunction, emphasizing the need for natural protective agents (Rahim *et al.*, 2023). Naturally occurring oils are esters of long-chain carboxylic acids; these lipids belong to the saponifiable group and are naturally occurring substances that are largely soluble in polar and non-polar chemical solvents but somewhat insoluble in water (Fotsing *et al.*, 2022). Small amounts of additional lipids, such as phosphatides, unsaponifiable components, and free fatty acids, can be found naturally in oils (Khalid *et al.*, 2023).

Hydrogen peroxide (H_2O_2) is a liquid that is covalently bonded, pale blue, miscible in vast quantities with water, and appears to flow right through cell membranes. H_2O_2 becomes cytotoxic to numerous types of animal, plant, and bacterial cells when they are exposed to high (often 50 μM) levels of it. The primary source of H_2O_2 hazard is its propensity to quickly change into the highly reactive hydroxyl radical (OH), either directly from UV radiation or indirectly. Furthermore, it can occur when it comes into contact with transition metal ions, of which iron is the most significant in vivo (Halliwell, 2000). Hydrogen peroxide (H_2O_2) aggravates renal cellular damage (Kadam *et al.*, 2017).

The kidney serves as the body's main organ required for a number of critical processes, such as excretion of hazardous metabolites, control of extracellular fluids, and detoxification (Al-Naimi *et al.*, 2019). Nephrotoxicity is defined as a rapid deterioration in kidney function due to the toxic effect of chemicals and medications. Exogenous or endogenous toxins that lead to oxidative stress also negatively impact renal function and can also cause damage to the kidneys, leading to nephrotoxicity (Al-Naimi *et al.*, 2019). These toxins may consist of fungi, molds, metals like arsenic, lead, and mercury, antibiotics like aminoglycosides, cancer treatments like cisplatin, and illicit drugs like cocaine (Lillie *et al.*, 2018). Nephrotoxins are chemicals that exhibit nephrotoxicity, i.e., they are capable of causing renal damage and injury (Campos *et al.*, 2018). Serum creatinine and blood urea are specific but have little sensitivity in the identification of early kidney injury, making them the classic indicators of nephrotoxicity and renal dysfunction (Campos *et al.*, 2018). The use of natural substances for nephrotoxicity prevention is crucial because of their antioxidant and anti-inflammatory properties. Nevertheless, little is currently known about these naturally occurring substances that may protect against kidney damage caused by drugs or chemicals (Džidić-Krivić *et al.*, 2023). This study aims to assess the physicochemical properties of these oils and their efficacy in ameliorating H_2O_2-induced renal toxicity in Wistar rats.

MATERIALS AND METHODS

Sample Collection

Fifty kilograms (50 kg) of locally grown ripe mango with a pH of 5.9 (called Chuwkpev in the Tiv language) was gathered from Gboko Local Government Area in Benue State. Cotton seeds (10 kg) and Coconut (50 pieces) were purchased at Sabon Gari Market in Kano State and Wadata Market in Makurdi, Benue State, respectively. The collected samples were identified at the Department of Biological Sciences Herbarium of Benue State University Makurdi. The herbarium index number allocated was HBI-COO-001-BSU24.

Sample Preparation

The Mango seed kernels were manually removed after they were sun-dried for three days. The kernels were chopped and then dried at 50 °C for 12 hours, leaving 7% w/w of moisture. A tray was used to blow away the thin cover. The dry material was grounded using a stainless steel grinder into powder, sealed in a plastic bag, and stored in the freezer until extraction to prevent oxidation (Sikdar *et al.*, 2017).

The coconuts were hand-shredded into fine, uniform-sized particles after they were cleansed and disheveled (Okene and Evbuomwan, 2014) and oven-dried to a moisture content of 7% at 60 °C. The obtained coconut meat was crushed and stored until extraction (Ghani *et al.*, 2018).

The cotton seeds were obtained by removing/ breaking the external cover mechanically. These seed samples were cleaned with water and treated using commercial concentrated sulphuric acid at 100 mL/kg and sundried for three days. The samples were ground into powder using a stainless steel grinder. Each sample was mixed between grindings to lessen caking and separation by particle size (Quampah *et al.*, 2012; Zerihun and Berhe, 2018).

Extraction of Oil from Mango, Coconut, and Cotton seed

Fifty (50 g) of kernel powder was added to the thimble, and n-hexane of approximately 300 mL was added to a 500 mL round-bottom flask. Using a Soxhlet apparatus, the device was heated to 70 °C and left under continuous extraction for 6 h. In order to retrieve the extraction solvent from the oil, the resultant mixture, or miscella, is distilled off at the end of the extraction process. The yield total was reported as a percentage. The total yield of the three oils was reported as a percentage (Mas' ud *et al.*, 2017; AOAC, 2019) .

$$\% \text{ Oil yield} = \frac{\text{Weight of oil}}{\text{Weight of sample}} \times 100 \quad (1)$$

Physicochemical Properties of Mango, Coconut, and Cotton Seed Oil

The physicochemical properties such as Peroxide value (AOCS, 2009), Acid value (Kamalu *et al.*, 2022), Saponification value (Nzelu *et al.*, 2016), Iodine value (Nadeem *et al.*, 2013), Specific gravity (Morris, 1999; Zerihun and Berhe 2018), Melting point (AOAC, 2019), Moisture content (Firestone, 2009; AOCS, 2017), Flashpoint (AOCS, 2017), Smoke point (AOCS, 2017), pH value (AOAC, 2016), Unsaponifiable Matter (Varona *et al.*, 2021) and Free Fatty Acids (% Oleic) (AOCS, 2017) were determined in the oils.

Ethical Approval

The ethical committee of the College of Health Sciences, Benue State University Makurdi, approved prior to the start of the experiments involving the use of animals. The ethical consent of this study is CREC/THS/005.

Experimental Animals

Thirty Albino Wistar rats were obtained and housed at the animal house of the College of Health Sciences, Benue State University Makurdi, to acclimatize for two weeks before the commencement of analysis. The animals had unlimited access to clean drinking water and were given a regular commercial pellet growers diet (Vital Feed, Nigeria).

Experimental Design

Thirty healthy Albino Wistar Rats weighing between 140 and 180 g were used for this research. They were randomly grouped into six groups. The animals' weights were examined to confirm a difference in weight of +/- 5 g between and within cages. Following acclimatization, the experimental rats were assigned into groups: Group 1 acted as the negative control (fed only chow), and Groups 2-6 were inoculated orally with 0.1 mL/kg body weight of 5 % v/v H_2O_2. Group 2, which served as the positive (H_2O_2) control, was not treated with the oils. From day 1 to day 14, groups 3-6 were administered 0.1 mL of H_2O_2 and 0.2 mL of each of the following: Mango kernel oil, Coconut oil, Cotton seed oil, and vitamin E. The standard group was Group 6 (Vitamin E). On day fifteen, the rats were sacrificed while under light chloroform anaesthesia. The blood sample of each rat was collected via the jugular vein into a plain tube and allowed to coagulate for 15 min. Samples were centrifuged for 10 minutes at 2500 rpm after allowing 15 min to coagulate. Biochemical studies of the kidneys were performed on serum from each sample. The animals were dissected, and the kidneys were taken out for histopathological investigation (Okagu *et al.*, 2020).

Determination of Kidney Markers

The Serum urea was determined using the diacetylmonoxime method (Patlolla *et al.*, 2018), and creatinine was analysed using a Randox kit (CR2789, Randox Laboratories, India) (Aitken *et al.*, 2013; Sinaga *et al.*,2019).

Histopathological Study

Fresh kidneys were removed from each rat, cleaned in 1 % ice-cold saline solution, and then preserved in 10 % neutral buffered formalin. Varying grades of ethanol (70, 80, 90, 95, and 100 %) were used to dehydrate the fixed tissues. After dehydration, the samples were cleared in two xylene changes. Following three successive impregnations of molten paraffin wax, tissue samples were embedded and sealed. Using a Microm HM 360 microtome, the paraffin blocks were cut into ribbons with 4 µm thick sections and then placed on a glass microscope slide. After staining the slides with a Microm HMS-70 stainer, they were viewed under a Nikon Eclipse E 800 microscope at X400 magnification. For histopathological analysis, at least four randomly selected sections per slide and four distinct fields were evaluated to ensure a comprehensive and representative examination of the tissue sample (Patlolla *et al.*, 2018).

Statistical Analysis

The data was analysed using SPSS version 21 for multiple factor analysis of variance (ANOVA) and correlation analyses. The data was reported as the mean value ± standard deviation of triplicates. The post hoc Duncan multiple range test was employed in multiple comparisons to assess significant differences in the data with a confidence level of $P < 0.05$.

RESULTS

The result of the physicochemical properties of mango kernel, coconut kernel, and cottonseed oils are presented in Tables 1a & b. Oil yield was 12.06 %, 65.29 %, and 35.18 % for mango, coconut, and cottonseed oils, respectively. Mango seed oil was solid at room temperature (25 °C); at 32 °C and above, it was liquid; coconut oil and cotton seed oil were both liquid at the various temperatures. They all had pleasant odours with mango kernel oil having a golden yellow colour, and coconut oil pale gold, and cotton seed oil golden brown. The result of the melting point showed that mango kernel oil had a melting point of 29.25 °C, coconut oil 23.25 °C, and cotton seed oil

28.25 ºC. Mango kernel oil had a higher melting point, followed by cottonseed oil, while coconut oil had the least. The specific gravity of mango kernel oil, coconut oil, and cotton seed oil was 0.89, 0.91, and 0.88, respectively. The mean values of the flash point of the oils are as follows: mango kernel oil 262.25 ºC, coconut oil 220.75 ºC, and cotton seed oil 302.45 ºC. The moisture content of mango kernel oil, coconut oil, and cotton seed oil was discovered to be 0.33, 0.09, and 0.35, respectively. The result of the pH of mango kernel oil was 4.88, coconut oil 6.97 and cotton seed oil 6.15. The mean value of the smoke points 250.73, 192.92, and 230.52 was recorded for mango kernel, coconut, and cotton seed oils, respectively. Mango kernel oil (1.70 meq/kg), coconut oil (0.52 meq/kg), and cottonseed oil (3.43 meq/kg) had the following mean for peroxide values. Mango kernel oil, coconut oil, and cotton seed oil were found to have acid values of 5.78 mg/KOH/g, 0.35 mg/KOH/g, and 6.82 mg/KOH/g, respectively. The iodine value of coconut oil was 17.53, cottonseed oil was 42.16, and mango kernel oil was 39.11. The mean for the saponification values of mango kernel oil, coconut oil, and cotton seed oil were 142.39 mg/KOH/g, 258.98 mg/KOH/g, and 180.31 mg/KOH/g, respectively. The following values were revealed by the unsaponifiable matter in the oils: coconut oil (0.42), cottonseed oil (1.50), and mango kernel oil (1.46). Mango kernel oil, coconut oil, and cotton seed oil had percentages of free fatty acid of 2.14, 0.21, and 3.40, respectively.

Table 1a: Physical Properties of Mango, Coconut and Cotton Seed Oils

	Mango Kernel Oil	Coconut Oil	Cotton Seed Oil
Oil yield (%)	$12.06^{a}\pm0.01$	$65.29^{b}\pm4.95$	$35.18^{c}\pm0.28$
State (a) at room temp (25ºC)	Solid	Liquid	Liquid
(b) at (32ºC) and above	Liquid	Liquid	Liquid
Odour	Pleasant	Pleasant	Pleasant
Colour	Golden yellow	Pale gold	Golden brown
Melting point(ºC)	$29.25^{b}\pm0.96$	$23.25^{a}\pm0.96$	$28.25^{b}\pm0.96$
Specific Gravity at (24ºC)	$0.89^{ab}\pm0.01$	$0.91^{c}\pm0.01$	$0.88^{a}\pm0.01$
Moisture	$0.33^{b}\pm0.02$	$0.09^{a}\pm0.01$	$0.35^{c}\pm0.01$
Smoke point (ºC)	$250.73^{c}\pm1.15$	$192.92^{a}\pm0.10$	$230.52^{b}\pm1.29$
Flash point (ºC)	$262.25^{b}\pm0.96$	$220.75^{a}\pm0.96$	$302.45^{c}\pm2.20$
pH	$4.88^{a}\pm0.03$	$6.97^{c}\pm0.07$	$6.15^{b}\pm0.13$

Table 1b: Chemical Properties of Mango, Coconut and Cotton Seed Oils

	Mango Kernel Oil	Coconut Oil	Cotton Seed Oil
Peroxide Value (meq/kg)	$1.70^{b}\pm0.02$	$0.52^{a}\pm0.04$	$3.43^{c}\pm0.03$
Acid Value (mg/KOH/g)	$5.78^{b}\pm0.02$	$0.35^{a}\pm0.02$	$6.82^{c}\pm0.01$
Iodine value (g I_2/100g)	$39.11^{b}\pm0.34$	$17.53^{a}\pm0.05$	$42.16^{c}\pm0.34$
Saponification Value (mg/KOH/g)	$142.39^{a}\pm0.57$	$258.98^{b}\pm0.02$	$180.31^{c}\pm0.02$
Unsaponifiable Matter (% of total lipid)	$1.46^{b}\pm0.02$	$0.42^{a}\pm0.02$	$1.50^{c}\pm0.01$
Free fatty acid	$2.14^{b}\pm0.03$	$0.21^{a}\pm0.03$	$3.40^{c}\pm0.04$

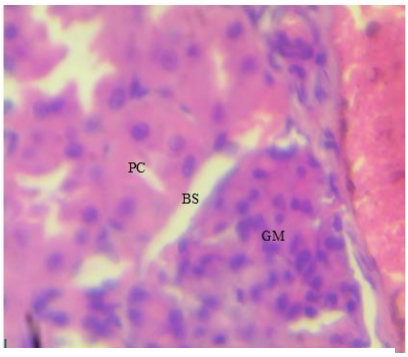
Values represent means of triplicate values ± sd(standard deviation) Mean in the same column with different superscripts are significantly different at ($p<0.05$).

The Kidney Markers of Albino Wistar Rats treated with the three oils are presented in Table 2. The mean values of the serum urea of Rats treated with mango, coconut, and cottonseed oils were 61.08, 64.05, and 65.60, and creatinine values observed in mango, coconut, and cottonseed oils were 1.12, 0.96, and 1.08, respectively. The photomicrographs of the kidneys are outlined in Plates 1a-1f.

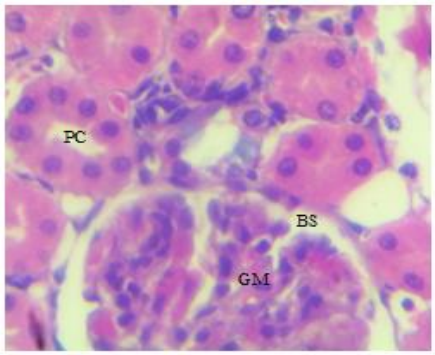
Table 2: Kidney Marker of Albino Wistar Rats treated with Mango kernel oil, Coconut oil, Cotton seed oil, and Vitamin E oils

Group	Urea (mmol/ L)	Creatinine (µmol/L)
Negative Control	$65.08^{a}\pm10.61$	$1.10^{ab}\pm00$
Positive Control	$78.75^{a}\pm13.19$	$1.25^{b}\pm0.23$
Mango Kernel Oil	$61.08^{a}\pm5.38$	$1.12^{ab}\pm0.08$
Coconut Oil	$64.05^{a}\pm16.17$	$0.96^{a}\pm0.24$
Cotton Seed Oil	$65.60^{a}\pm1.92$	$1.08^{ab}\pm0.08$
Vitamin E	$62.45^{a}\pm12.41$	$1.18^{ab}\pm0.06$

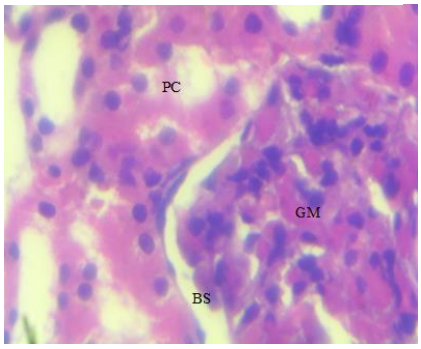
Values represent means of triplicate values ± sd(standard deviation) Mean in the same column with different superscripts are significantly different at ($p<0.05$).



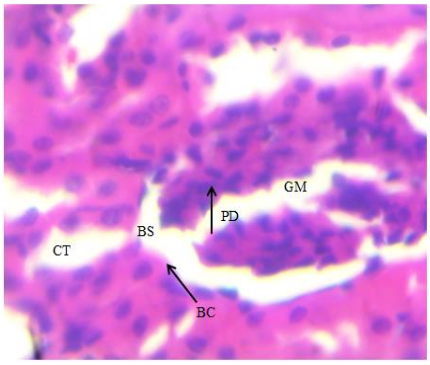
a. Negative control



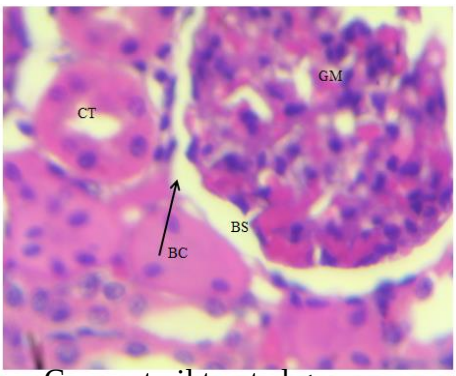
b. Positive control group



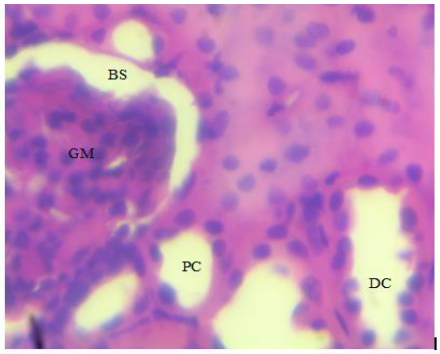
c. Mango kernel oil treated group



d. Cotton seed oil treated group



e. Coconut oil treated group



f. Vitamin E treated

Plate 1: Photomicrograph of the Kidney of Albino Wistar Rats
Keys: GM: Glomerulus, PC: Podocyte group, BC: Bowman's capsule, BS: Bowman's space, GM: Glomerulus, DC: Distal convoluted tubules, CT: Collecting tubules

DISCUSSION

The oil yield and physicochemical properties of the mango kernel, coconut kernel, and cottonseed are displayed in Tables 1a and 1b. The percentage yield of mango kernel oil compared favourable with literature values. (Kittiphoom and Sutasinee, 2013; Nzikou *et al.*, 2010; and (Asemave *et al.*, 2020). The percentage oil yield of coconut oil corresponds with the value obtained by (Krishna *et al.*, 2010; Ghani *et al.*, 2018), and that of cotton seed is a little bit lower than the value obtained by (Rojo-Gutiérrez *et al.*, 2020) but agrees with the values published by (Shah *et al.*, 2017; Zerihun and Berhe 2018).

A melting point of 29.25 ºC observed in mango kernel oil implies that it is relatively solid at room temperature. In general, oils with a melting point below room temperature (around 25 ºC) are considered liquid, while those with a melting point above room temperature are considered solid (Ikhuoria and Maliki, 2017). Significant differences exist at ($P<0.05$) between the values of coconut oil and mango kernel oil as well as coconut oil and cotton seed oil, while no significant difference existed between mango kernel oil and cotton seed oil. The melting point of mango kernel oil was lower than the amount discovered by Gurjar *et al.* (2022) and in close agreement with those reported by Mas'ud *et al.* (2018). The melting point of coconut oil is similar to the value obtained by Subroto *et al.* (2020). The melting point of the cotton seed oil is within the range obtained by Maliki *et al.* (2020) and higher than the value obtained by Zia *et al.* (2020).

The specific gravity of the oils corresponds with the FAO/WHO (2009) standard. There was no significant difference between the values of mango kernel oil and cotton seed oil, while between mango kernel oil and coconut oil, they differed significantly from one another ($p<0.05$). The value obtained from mango kernel oil closely corresponds with other literature (Yadav *et al.*, 2017). Coconut oil had a similar value gotten by Bello *et al.* (2015) and Ogbiede *et al.* (2022). The specific gravity of cottonseed oil is comparable and similar to values documented by Maliki *et al.* (2020). Studies by Mengistie *et al.* (2018) have linked high specific gravity levels to the presence of linoleic acid.

The temperature at which oil's vapour will ignite upon coming into contact with a source of ignition is known as the flash point of the oil (Gurjar *et al.*, 2022). The result of the flash point of the oil is significant at ($p<0.05$). The highest flash point was recorded in cottonseed oil, followed by mango seed oil. This implies that the oils can be used at a very high temperature without the risk of it igniting or producing harmful fumes. Additionally, oils with high flash points are less likely to produce off-flavours or other unwanted by-products when heated, and a lower value was recorded for coconut oil, implying that it is moderately volatile and can be safely heated to moderate temperatures (Perera *et al.*, 2020). Mango kernel oil had a flash point value within the range obtained by Gurjar *et al.* (2022), while the flash point value recorded for coconut oil corresponds with other literature (Perera *et al.*, 2020) and is lower than the value obtained by Bello *et al.*, (2015). Cotton seed oil had a flash point that was higher than the value obtained by Agu *et al.* (2024).

The moisture content of cottonseed oil was slightly higher than the value obtained in mango kernel oil, while coconut oil had the least. Both oils were slightly higher than the maximum permitted limit for edible oils (≤0.2%) according to Federation (2011), while coconut oil having the least falls within the allowable range. The moisture content of the oil samples was found to be in the range of 0.09%-0.3% (w/w), which is within the value recommended by APCC (<0.5% w/w) (Maurikaa *et al.*, 2020). There were notable differences in the oil samples' moisture content ($P<0.05$). The moisture content observed for coconut oil in this study was lower than the value obtained by Medeiros de Azevedo *et al.* (2020) and Maurikaa *et al.* (2020). Mango kernel oil had a value that corresponds with Gurjar *et al.* (2022), and cottonseed oil had a value lower than the result obtained by Muhammad *et al.* (2023). Because moisture in oil causes triglycerides to hydrolyze, which eventually results in rancidity, low moisture content is essential for edible oils in order to have a long shelf life (Negash *et al.*, 2019).

The pH of the oils is significantly different at ($P<0.05$). Studies have shown that pH affects the oxidative stability of oils (Gurja *et al.*, 2022). pH value of the mango kernel oil was somewhat more acidic than coconut oil and cotton seed oil. The slightly acidic nature of mango oil implies that the oil tends to react with other compounds that are present in food or cosmetics. Mango kernel oil had a value lower than what was reported by Gurja *et al.* (2022). The value obtained for coconut oil was higher than those reported by Martins *et al.* (2020), while cottonseed oil had a value higher than what was obtained by Muhammad *et al.* (2023).

Mango kernel oil had the highest smoke point, followed by cotton seed oil, and this implies that the oils can withstand higher temperatures before reaching its smoke point, making it

suitable for frying and deep frying. For this research, the least smoke point was observed in coconut oil. The medium to high smoke point observed in coconut oil makes it versatile for cooking methods like baking. The oil samples' smoke points varied significantly from one another. The smoke point of mango kernel oil corresponds with the findings of Gurjar *et al.* (2022), coconut oil's result is in line with the findings of Perera *et al.* (2020), and cottonseed oil is lower than the findings in the literature (Zia *et al.*, 2020). The smoke point of cooking oil is an essential characteristic because when oil is heated to a specific temperature, smoke that may contain hazardous free radicals and toxic gases is released (Gurjar *et al.*, 2022).

The lowest peroxide value was observed in coconut oil in this investigation, and cotton seed oil had the highest. These figures, however, are within the World Health Organization's (WHO) 1994-stated permissible maximum level of ≤10 meq/kg (Aremu *et al.*, 2015). According to Bustani & Soni (2023), oils with high peroxide value are more susceptible to oxidative rancidity, whereas oil with a lower value is more resistant to it, indicating a high level of antioxidants. Because of the low amount of peroxide values observed, the oils under investigation can, therefore be considered resistant to oxidative rancidity, and this also indicates that the oil is fresh, as the peroxide level in fresh oil is usually less than 10 meq/kg (Muhammed *et al.*, 2023). The samples differed significantly from one another ($P<0.05$). The Standard Organisation of Nigeria (SON) allowed peroxide value for edible oils to be ≤10 meq/kg oil, while rancid oils have values between 10 and 20 meq/ kg oil (Onoji *et al.*, 2016).

The oil with the highest acid value was cottonseed oil, followed by mango kernel oil, and the least was coconut oil. American Society for Testing and Materials (ASTM) states that vegetable oils' permitted acid value cannot be more than 2 mg/KOH/g (Yusuf *et al.*, 2015), and according to Martin *et al.* (2020), the acid value for crude oil is (4.0 mg KOH/g oil). While coconut oil was within the maximum acceptable limit established, the values obtained for mango kernel oil and cotton seed oil were above the permissible amount. Elevated amount of free fatty acids found in mango kernel and cottonseed oils may be the cause of their high acid values. A comparable outcome was achieved by Saiprabha *et al.* (2011); Gurja *et al.* (2022) for mango kernel oil. Value of coconut oil was less than the outcome by Bello *et al.* (2015) and within the value obtained by Martin *et al.* (2020). Oils with low acid numbers are generally reported to have high saponification values (Muhammed *et al.*, 2023); low acid values in oils also suggest long-term stability and protection against peroxidation and rancidity. This may be explained by the seeds' inherent antioxidants, which include vitamins A and C, as well as other potential phytochemicals, including flavonoids. Their acid value measures the quantity of free fatty acids in fats and oils. It shows how rancid, spoiled, edible, or deteriorated the oil is. The acid value is the mg/KOH required to neutralize the free fatty acid in 1 g of oil. The extent to which glycerides in oil are decomposed by lipases and other actions, such as light and heat, is measured by the acid value (Mas'ud *et al.*, 2018).

The iodine value gauges the level of oil unsaturation. One characteristic of a high iodine value is high unsaturation. It is the gram count of iodine required to saturate 100 g of fat or oil. Since they are unable to absorb any iodine, saturated oils, and fats have a zero iodine value (Maliki *et al.*, 2020). Cotton seed oil had the highest iodine value with coconut oil having the least. The iodine value obtained for mango kernel oil and cotton seed oil indicates that the oil contained appreciable levels of unsaturated fatty acids (Mas'ud *et al.*, 2018; Muhammad *et al.*, 2023). The value of mango kernel oil is lower than the findings of Mas'ud *et al.* (2018), Sahar 2018 and Gurjar *et al.* (2022). Coconut oil had a value slightly lower than what was obtained by Martins *et al.* (2020). Cotton seed oil value was lower than those reported by Muhammad *et al.* (2023). The iodine value also measures the drying ability of oils, it serves as the foundation for the classification of fats and oils into three categories: drying (iodine value greater than 150 g I_2/100g), semi-drying (iodine value between 100 and 150 g I_2/100g) and non-drying (iodine value less than 100 g I_2/100g) (Maliki *et al.*, 2020; Ogbiede *et al.*, 2022).

Coconut oil had a high percentage of easily saponified fatty acids, as shown by its high saponification value. The oils' saponification values differ significantly ($P<0.05$). From this study, it was observed that the saponification value of mango kernel oil was higher compared to the value obtained by Gurja *et al.* (2022); however, Kittiphoom and Sutasinee (2013) also found higher values. According to the research by Ogbiede *et al.*, (2022), the value of saponification value observed for coconut oil was slightly lower. Cotton seed oil had a comparable result with the findings of Maliki *et al.* (2020). One special quality that makes oil suitable for use in soap production and other skin care products is its high saponification

value, which indicates a high proportion of low- to medium-chain fatty acids (Vidal *et al.*, 2020). Ogbiede *et al.* (2022) have claimed that medium-chain fatty acids have been discovered to have weight loss properties and are becoming a popular supplement among body builders and athletes. They have also been utilised in food and nutrition. A low saponification value suggests a high molecular weight of the fatty acid present in the oil, whereas a high saponification value signifies a low molecular weight of the triglyceride. Additionally, the saponification value shows if the oil has been adulterated or is pure (Aremu *et al.*, 2015; Omari *et al.*, 2015).

Mango kernel oil has been found to have less unsaponifiable matter than previously reported (Nzikou *et al.*, 2010) and more than the findings obtained by Gurjar *et al.* (2022). The coconut oil value is similar to what was obtained in another research (Gopala Krishna *et al.*, 2010) and higher than what was obtained by Maurikaa *et al.*, (2020). The value of cotton seed oil was higher than what was recorded by Zia *et al.* (2020) and less than what was stated in the literature reported by Bozdogan Konuskan *et al.* (2015). The majority of efforts to characterize oils and fats have concentrated on their principal components, which make up the saponifiable fraction and account for more than 95 % of oils and fats. However, it is now well acknowledged that the smaller constituents, which make up the unsaponifiable matter in most cases, have important nutritional, bioactive, and compositional qualities that influence the quality of specific oils and fats. Unsaponifiable matter makes up 1-2 % of the minor components, while triglycerides make up around 98 % of the major components of vegetable oils (Sakdar *et al.*, 2017). According to Sakdar *et al.*, (2017). the unsaponifiable matter portion of vegetable oils consists of compounds dissolved in fat that are soluble in an organic solvent during saponification but insoluble in an aqueous solution, which has anti-inflammatory and antioxidant capabilities. These substances naturally contain hydrocarbons (squalene), triterpene alcohols, fatty alcohols, sterols, tocopherols, and other phenolic compounds.

According to the analysis of the oils under investigation, the percentage of free fatty acids was 2.14 % in mango kernel oil, 0.21 % in coconut oil, and 3.40 % in cottonseed oil. Mango kernel oil had a greater free fatty acid value than what Kittiphoom and Sutasinee (2013) found. Coconut oil's worth is less than that of the findings by Perera *et al.* (2020), and cotton seed oil's value is less than that of the findings published in the literature by Aremu *et al.* (2015) and corresponds to the findings of Maurikaa *et al.*, (2020). The oils under investigation had an overall fatty acid content of less than 5 %, which is within the recommended level of 5 % in literature by Ikhuoria and Maliki (2007), and this suggests that the oils had little potential to develop rancidity.

The hydrolysis of oils and fats produces FFA and is susceptible to oxidation (Maurikaa *et al.*, 2020). According to Aremu *et al.* (2015), free fatty acid is the proportion of a particular fatty acid by weight, such as oleic acid. High concentrations of free fatty acids, particularly linoleic acid, can diminish an oil's shelf life and produce off-flavours, which makes them undesirable in finished oils. An indicator of edible oil's overall quality is the amount of free fatty acid it contains. They can originate in the later phases of oxidation or by hydrolysis. Excessive quantity of free fatty acids causes the oil to "pop" during frying and lowers the oil's smoke point. Free fatty acid content is low in premium oils (Aremu *et al.*, 2015). Edible oil's desirability increases with decreasing free acid content (Maliki *et al.*, 2020).

Progressive damage in the kidneys can be measured clinically by measuring serum creatinine and urea levels (Sinaga *et al.*, 2019). Renal function indicators are shown in Table 2. Elevations in serum creatinine and urea are significant indicators of renal toxicity. Serum urea buildup that is greater than its clearance rate might result in kidney disease and dysfunction. Likewise, elevated levels of plasma creatinine are seen as a disturbance of nephron function (Yousef *et al.*, 2010). The positive control (non-treated) group showed an increased level of urea and creatinine, and this could be a result of the strong oxidative, cytotoxic, and genotoxic effects of hydrogen peroxide (Milev *et al.*, 2022).

In comparison to the positive control group, the serum levels of creatinine and urea were considerably lower in the rats that received the oils. There was a significant difference ($P<0.05$) in the result of the creatinine levels; however, the results for urea showed no significant difference ($P<0.05$). The primary site of creatinine synthesis is the liver, and increased creatinine levels are indicative of nephron and kidney impairment. The kidney removes creatinine and urea, which are nitrogenous compounds that are not proteins, mostly through glomerular filtration and proximal tubular secretion (Ndukaku *et al.*, 2015).

The biochemical improvements observed in this study could be attributed to the antioxidant potential of the essential components of mango kernel, coconut kernel, and cottonseed oils. Milev *et al*. (2022) recorded the presence of antioxidants, including tocopherol, tocotrienol, flavonoids, and some polyphenol compounds in coconut oil.

The kidney photomicrographs of the negative control group (Plate 1a) showed that it was covered externally with a thin layer of fibrous tissue, the renal capsule. The kidney tissue consists of two parts: the outer part (the renal cortex) and the inner one (the medulla). Larger proteins and cells are kept in the bloodstream by the glomeruli of the kidneys, where specialised cells called podocytes form the filtration barrier that lets fluid and tiny molecules flow through. The area that the filtrate first flows into after passing through the glomerulus is known as Bowman's space. Bowman's capsule is the membrane that encloses Bowman's space, and glomeruli are microscopic kidney structures that are essential for blood filtration with characteristics including renal tubules, bowman's capsule (BC), glomerulus (GM), bowman's space (BS) and podocytes (Mahran *et al*., 2022) signifying a normal kidney function and cell architecture.

The positive control (non-treated) group exhibited a densely packed podocyte population surrounding the glomerulus, signifying intermediate nephritis or kidney inflammation. A disease known as glomerulosclerosis may be indicated by densely packed podocytes surrounding the glomerulus and also hardening and scarring of blood vessels (Elkholy et *al*., 2024). Reduced kidney function and renal disease may result from this type of kidney scarring.

The podocyte plays a critical role in maintaining normal glomerular architecture and it is a primary focus in many kidney diseases. Less densely packed podocytes with normal cell architecture were observed in the glomerulus of the cotton seed oil-treated group. This disease is referred to as focused podocytopenia (Zeng *et al*., 2024). The podocytes may have moved out of the glomerulus or have died off.

A kidney with multifocal nephritis, a form of renal disease characterised by inflammation in various locations of the kidney, was seen in the group that received mango kernel oil treatment. A reduced number of cells were observed in the vicinity of the renal tubules' collecting tubules (CT), proximal convoluted tubule (PCT), and distal convoluted tubule (DCT). Additionally, an atypical podocyte population was observed in the glomerulus, suggesting the possibility of renal injury (Singh *et al*., 2023).

The group that received coconut oil treatment showed indications of the glomerular membrane (GM) and convoluted tubules (CT) being restored. This implies that the oil may have repaired part of the kidney damage. According to Ochida *et al*. (2024), Coconut oil has an in vitro and invivo antioxidant activity, and this may have contributed to its ability to repair the H_2O_2-induced damage to the kidney. Ajeigbe *et al*. (2024) reported the intervention of coconut oil on trichloroacetic acid-induced toxicity in the hepato-renal system.

The kidneys in the vitamin E group had their collecting tubules and glomerulus restored. This suggests that part of the renal damage that had occurred was repaired. Restoration of the collecting tubules and glomeruli suggests that the kidney has partially recovered and can continue to operate until it is fully repaired. The restorative role of vitamin E against H_2O_2-induced damage may be closely related to its solid antioxidative capacity (Milev *et al*., 2022).

A study was conducted by Mahran et *al*. (2022) where it was reported that Moringa oleifera oil improved the nephrotoxicity induced by sofosbuvir via improving the histopathological, immunohistochemical, and biochemical changes due to its high level of different antioxidant, anti-inflammatory and anti-apoptotic components. The protective effect of argan oil against betamethasone-induced oxidative renal damage in rats through its antioxidant, anti-apoptotic, and proliferative potency was reported by Orabi *et al*. (2020).

CONCLUSION

The findings from the physicochemical properties of mango kernel, coconut kernel, and cottonseed oils showed that they had a high oil yield. The flash point of the oils under study implies that the oils can be used at a very high temperature without the risk of igniting. Lower peroxide values observed in oils show their resistance to oxidative rancidity, which may indicate high levels or the presence of antioxidants; low-iodine values observed in coconut oil showed that they are less prone to rancidity and more stable. The unsaponifiable matter in the oils showed that they may contain important nutritional, bioactive, and compositional qualities that influence the quality of the specific oils. The biochemical analysis showed that the oils had an ameliorating effect on hydrogen peroxide-induced kidney toxicity.

Phytochemicals in the oils may be responsible for their ability to ameliorate renal toxicity by lowering the creatinine and urea levels in the serum. The histopathology examination of the kidney in the negative control group showed no pathological changes, while the positive control group showed many pathological changes. Some varying degrees of damage and inflammation were still being noticed in some specific areas in the group treated with cotton seed and mango kernel oils, while the coconut oil and Vitamin E group showed an obvious degree of recovery, which may be attributed to higher antioxidant and anti-inflammatory properties. Administering mango kernel and cottonseed oils at a dosage slightly higher than what was used in this study may yield a positive outcome.

Conflict of Interest

The authors declare no conflict of interest.

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