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RESEARCH ARTICLE

Evaluation of Cholesterol Level and Physicochemical Analysis of Five Selected oils from Vegetable and Animal Sources

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Abstract

This study investigates the evaluation of cholesterol levels and analysis of five selected oils from vegetable and animal sources. Dietary oils are crucial in human nutrition, serving as a concentrated energy source. As the global understanding of health and nutrition evolves, there is an increasing emphasis on scrutinizing the nutritional content of oils derived from vegetable and animal sources. The analysis in this study was done according to the standard methods. The results of the cholesterol content of the selected oils analyzed indicated that fish oil has the highest cholesterol content (1.62 mg/g), followed by pork oil (1.11 mg/g) and ram oil (0.87 mg/g) while groundnut and coconut oil have comparable lower cholesterol content of 0.07 mg/g, and 0.09 mg/g respectively. The chemical analysis of the selected five oils followed the trend indicated below; peroxide value (Millimoles per 100g): coconut oil (1.31) > pork oil (1.11) > groundnut oil (0.99) > fish oil (0.55) > ram oil (0.49). Free fatty acid (%): groundnut oil (13.75) > coconut oil (8.70) > fish oil (5.61) > pork oil (5.33) > ram oil (4.77). Saponification value (Mg KOH/g): coconut oil (258.38) > groundnut oil (197.93) > ram oil (187.05) > fish oil (168.700) > pork oil > (150.000). Iodine Value (Mg of iodine per 100 g oil): pork oil (200.50) > groundnut oil (161.00) > fish oil (65.50) > ram oil (60.00) > coconut oil (10.75). The analysis of the oils investigated in this study offers a comprehensive understanding of their composition, quality, and potential implications for health and industrial applications.

Introduction

Dietary oils are vital to human nutrition because they play important roles in many body processes in addition to serving as a dense source of energy [1]. These oils are the second most important source of dietary calories. Triglyceride molecules made from glycerol and three fatty acid chains make up the majority of vegetable oils [2]. They also contain trace amounts of diglycerides,

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phytosterols, vitamins, polyphenols, and tocopherols [3]. These bioactive substances should be retained throughout processing since they are beneficial to general health. Oils can also contain unwanted materials including free fatty acids, waxes, pigments, and oxidative byproducts like aldehydes and peroxides, which can shorten their shelf life and lower their quality [4]. Lipids, which are non-volatile, water-insoluble compounds that easily dissolve in organic solvents, include fats and oils. As necessary sources of fatty acids, they are crucial components of our daily diet [5]. Saturated and unsaturated fatty acids are the two types of fatty acids [6]. Overconsumption of saturated fats has been linked to cardiovascular disease, even although they are solid at room temperature and are often found in animal products and tropical oils such as palm and coconut oil. On the other hand, it is well known that unsaturated fats are good for health. These include monounsaturated fats (for example, olive oil and avocados) and polyunsaturated fats (for example, omega-3s and omega-6s found in fish and vegetable oils), which contain one or more double bonds in their carbon chains, thereby enhancing their biological functions and structural fluidity [7]. These fats are beneficial to brain function, inflammation management, and heart health. As a result, health professionals frequently recommend replacing saturated fats with unsaturated fats to reduce the risk of disease and enhance overall wellness [8]. Although, plant-based oils have a complicated and multifactorial impact on blood lipid profiles and cardiovascular health [9], they do not naturally contain cholesterol [10]. On the other hand, oils originating from animals usually include cholesterol. Even though fish oils are high in heart-healthy omega-3 fatty acids, they nevertheless contain trace quantities of cholesterol [11]. The main sterol found in animal fats, cholesterol, is essential to human life in a number of ways. It is vital for embryonic development, supports the neurological and reproductive systems, and aids

in maintaining the integrity of cell membranes. Cholesterol is insoluble in water; it must attach itself to proteins in order to pass through the bloodstream to form lipoproteins [12]. On the other hand, high cholesterol is linked to atherosclerosis and other long-term health problems. As illustrated in figure 1, the objective of this study is to methodically examine the Physio-chemical composition and cholesterol level of five selected oils derived from both plants and animals. This study aims to close the knowledge gap and provide insights that will help consumers make healthy dietary selections and benefit the scientific community because the lack of comparable data on the topic makes it difficult to make educated dietary choices.

Materials and Methods

Sample collection

The oil samples were collected within Wukari metropolis in Taraba State, Nigeria and hygienically kept in bottles for further analysis.

Extraction of oils

Animal oils including fish oil, pork oil, and ram oil were obtained by gently simmering the respective meats and fats at 85 °C until a sufficient amount of oil was released. In contrast, plant oils were extracted using a different approach: dried groundnuts and coconuts were first ground into a fine paste using a blender.

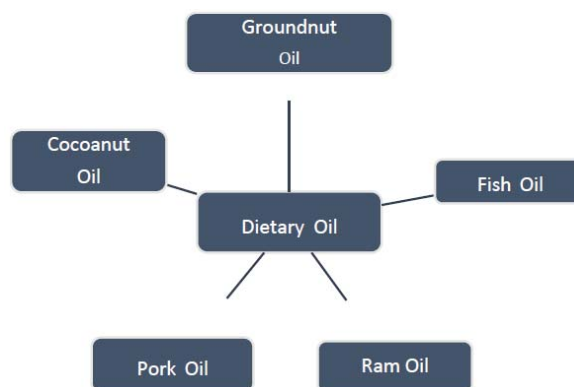


Figure 1 Dietary oils from plants and animal sources.

This paste was then subjected to mechanical pressing to extract the oils. The resulting oils were carefully filtered to remove residual solids and impurities, producing pure groundnut and coconut oils.

Determination of Cholesterol

Spectrophotometric method used in accordance with the procedure described by [13]. A water bath kept at 50°C was used to evaporate 0.1 mL of the sample and the cholesterol standard, both of which were produced in a 1:10 chloroform solution. To make sure the cholesterol was completely dissolved, 3.0 mL of glacial acetic acid and 3.0 mL of a color reagent were added to the dried residues and vigorously shaken. To prepare the blank, 2mL of chloroform, 3mL of glacial acetic acid, and 3mL of color reagent were mixed. The absorbance of the samples and standard was measured at 560 nm following a 30 minutes cooling period at room temperature.

Determination of Peroxide value

In a 250 mL stoppered flask, 0.3 g of oil was dissolved in a chloroform-acetic acid mixture to evaluate the peroxide value using the standard method or iodometric method [14]. After adding one milliliter of saturated potassium iodide solution, the flask was covered and left in the dark for 5 min. The released iodine was titrated with 0.01N sodium thiosulfate until pale yellow was seen after adding 20 mL of distilled water and gently swirling. Then, 1 mL of 1.5% starch indicator was added and titration continued until the solution became colorless.

Determination of free Fatty acid

A 250 mL conical flask was filled with 0.5 g of the sample in order to measure the free fatty acid. Next, 1 mL of phenolphthalein indicator and 50 mL of recently neutralized hot ethyl alcohol were added. The mixture was heated for 15 min at 75- 80°C in a water bath, cooled to

roughly 40°C, and then titrated with a standard alkali solution while hot, shaking vigorously until the endpoint was attained.

Determination of Saponification value

After the samples were dried and filtered to get rid of moisture and contaminants, 2.0 grams were weighed into a 250 mL Erlenmeyer flask. They were refluxed for an hour in a water bath with 25 mL of 0.5N alcoholic KOH and anti-bumping granules. Ten milliliters of hot ethyl alcohol neutral to phenolphthalein were used to rinse the flask and condenser once they had cooled. The heated solution was then titrated with 0.5N HCl after 1 mL of 1 % phenolphthalein was added. Under the same conditions, a blank test was conducted and values were recorded.

Determination of Iodine value

A 500 mL stoppered conical flask was filled with a weighed oil sample, 25 mL of carbon tetrachloride, and 25 mL of Wijs solution. After adding the potassium iodide solution, the mixture was stirred and left in the dark for one hour for drying oils and thirty minutes for non-drying or semi-drying oils. Next, 100 mL of heated, cooled water and 15 mL of potassium iodide solution were added. Using starch as an indication, the released iodine was titrated with standardized sodium thiosulfate until the blue colour vanished. Concurrently, a blank determination was carried out without the oil sample [14].

Results and Discussions

Cholesterol content

The cholesterol content of various oils derived from plants and animals, measured in milligrams per gram is displayed in figure 2. The plant-based oils, groundnut oil and coconut oil exhibited the negligible cholesterol content, with values 0.046 mg/g and 0.081 mg/g respectively. These values are equivalent to 0.0046 % and 0.008% cholesterol by mass which is extremely

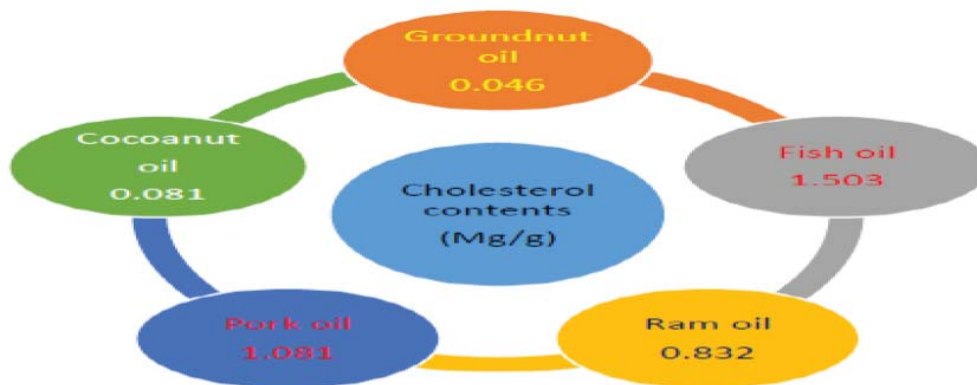


Figure 2 Cholesterol Content of the five selected oils sourced from plant and animals.

low. Also according to [15] groundnut oil has little to no cholesterol. In comparison to estimated sterol (190–250mg/100g) for groundnut oil and (60–80mg/100mg) for coconut oil, the values obtained are lower than the estimated sterols for both oils. Fish oil, derived from animals, indicated the highest cholesterol content (1.503 mg/g) in this study. The range of cholesterol content normally falls between the ranges of 0.1–2.04 mg/g [16]. Similarly, pork oil and Ram oil showed high cholesterol levels, with values 1.087 mg/g and 0.832 mg/g. According to these findings, oils derived from animals often have greater cholesterol levels, which may have consequences for dietary decisions and health issues pertaining to cholesterol consumption. Oils derived from plants, like coconut oil and groundnut (peanut) oil, are free of cholesterol. However, groundnut oil, which is rich in monounsaturated and polyunsaturated fatty acids, is typically linked to more favorable lipid profiles, while coconut oil may raise LDL-cholesterol because of its high saturated fatty acid content [17].

Saturated and Trans fats, on the other hand, are known to raise low-density lipoprotein (LDL) cholesterol and raise the risk of cardiovascular disease (CVD). Previous correlations between dietary cholesterol and cardiovascular outcomes are complicated by the high quantities of saturated fat found in foods high in cholesterol [18]. Therefore, rather than just cholesterol, the

total fat content of the diet has a significant impact on the cardiovascular effects of cholesterol-containing foods. Due to compensatory mechanisms such as decreased endogenous synthesis and higher bile acid excretion; several studies have shown that dietary cholesterol has only a slight impact on blood total and LDL-cholesterol in the majority of people [19]. There is inter-individual heterogeneity; so-called "hyper-responders" have mild increases in LDL cholesterol, which are frequently accompanied by parallel increases in high-density lipoprotein (HDL) cholesterol and cause the LDL/HDL ratio to vary very little [20]. Dietary cholesterol intake is not independently linked to an elevated risk of cardiovascular disease (CVD) in the general population, according to epidemiological and clinical research. Moderate consumption of eggs or dietary cholesterol has not been linked to coronary heart disease or stroke, according to large cohort studies and meta-analyses [19,21]. As a result, rigid numerical limitations on dietary cholesterol intake have been less stressed in contemporary dietary guidelines.

Nutritional Components of the oils

The nutritional Components of the five selected oils (Groundnut oil, Coconut oil, Fish oil, Pork oil and Ram oil) were analyzed for Peroxide Value (milimoles/1000g), % Free Fatty Acid (as oleic), Saponification Value (Mg KOH/g), Iodine value (Mg of iodine per 100g oil)

from both plant and animal sources as shown in table 1 and figure 3.

Peroxide values

Table 1 and figure 3 above indicate the peroxide values of the different oils analyzed. The peroxide value (POV) measures the extent of oxidation in oils, reflecting their freshness and susceptibility to rancidity. Coconut oil showed the highest POV (1.31value Millimoles per 1000 grams) compared to other oils analyzed, suggesting moderate susceptibility to oxidation. According to the Philippine National Standard the standard peroxide value of coconut oil should be less than 1.5 millimoles/1000g [22]. Pork oil and groundnut oil exhibited slightly lower POV values, which are 1.105 and 0.99 millimoles per 1000 grams respectively, indicating better oxidative stability compared to coconut oil.

Fish oil and Ram oil indicated lower POV values of 0.545 and 0.485 millimoles per 1000 grams respectively, suggesting higher resistance to oxidation. A key metric in the analysis of oils is the peroxide value (POV), which provides information about the stability, freshness, and quality of the oils. The POV makes it possible to evaluate oil quality and shelf life by measuring the concentration of peroxides, which are the main byproducts of lipid oxidation. This helps determine taste, aroma, and nutritional integrity [23]. In general, oils with lower POV values have longer shelf lives, are less prone to rancidity, and pose less health hazards due to oxidative deterioration. Additionally, POV measurements are crucial for food industry quality management, ensuring that oils fulfill consumer expectations and legal requirements. In general, knowing and keeping an eye on

Table 1: Nutritional Components of the five selected oils from both plant and animal sources.

S/N	Parameters	Groundnut oil	Coconut oil	Fish oil	Pork oil	Ram oil
1.	Peroxide Value (milimoles/1000g)	0.99	1.31	0.55	1.11	0.49
2.	% Free Fatty Acid (as oleic)	13.75	8.70	5.61	5.33	4.77
3.	Saponification Value (Mg KOH/g)	197.93	258.38	168.70	150.00	197.05
4.	Iodine value (Mg of iodine per 100g oil)	161.00	10.75	65.50	200.50	60.00



Figure 3 Nutritional Components of the five selected oils from both plant and animal sources.

the POV helps make well-informed decisions about the production and consumption of oils, improving both manufacturing and health procedures.

Free Fatty acid Value (FFA)

The free fatty acid value (FFA) of the selected oils are shown in table 2. The FFA of oils is an important parameter that indicates the degree of hydrolysis or breakdown of triglycerides into free fatty acids. In the provided table, each oil sample is represented by denoting the percentage of free fatty acids as oleic acid. Groundnut oil exhibited the highest FFA values (13.47%) among the oil studied, suggesting a higher degree of hydrolysis. Coconut oil indicated slightly low FFA value (8.70%) suggesting a moderate degree of hydrolysis. The values are above the standard for free fatty acid (0.3–0.65 and 0.03–0.5%) for both groundnut oil and coconut oil according to [24]. High level of free fatty acid may due to environmental factors associated with storage and processing methods. Fish oil, Pork oil and Ram oil showed lower FFA values; 5.61%, 5.33 % and 4.77 % respectively. This indicates better stability compared to groundnut oil and coconut oil. This is similar to the report of [25]. These findings show the stability and quality of the oils; lower FFA readings are typically linked to higher quality and longer shelf life. Because of increased triglyceride hydrolysis, which results in off-flavours, smells, and a shorter shelf life, higher FFA levels usually indicate lower oil quality. They may also indicate a greater vulnerability to rancidity and deterioration. In overall, FFA measures are essential for preserving product quality, fulfilling safety regulations, and building consumer trust in the food sector. To improve oil stability and customer satisfaction, FFA levels in oil production and storage operations must be monitored.

Saponification Values

The saponification values provided in table 2 offers valuable information into the composition

and characteristics of the oils analyzed. Saponification value, measured in milligrams of potassium hydroxide (KOH) per gram of oil or fat, indicates the average molecular weight of fatty acids present in the oils. Higher saponification values correspond to oils with shorter fatty acid chains (lower molecular weight), while lower values indicates longer fatty acid chains (higher molecular weight)

It was observed that coconut oil exhibited the highest saponification value; 258.375 mg KOH/g oil. This indicates that coconut oil contains fatty acids with relatively shorter molecular weights compared to other oils. Groundnut oil, Ram oil, fish oil, and pork oil follow in descending order of saponification values, 197.925, 187.050, 168.700, and 150.00 mg KOH/g oil respectively. These values are within the estimated saponification values for the oil according to [24,26]. This report is also similar to what has been reported by [27,28] for Pork oil, groundnut oil and fish oil respectively.

These findings show that the fatty acid makeup of the examined oils varied significantly. Coconut oil, which is well-known for having a high saturated fat content, exhibits comparatively greater saponification values, because they contain shorter-chain fatty acids with lower molecular weights. Oils like fish oil, which are high in polyunsaturated fatty acids like omega-3 fatty acids, have lower saponification values.

Comprehending the saponification values of oils is crucial for a number of uses, such as the production of soap, where oils with greater saponification values are favoured for creating soaps that are more durable and stable [29]. Furthermore, saponification values can shed light on the nutritional makeup and possible health advantages of oils. While oils with higher molecular weight fatty acids may have a higher energy density, excessive consumption of these oils may also raise cholesterol levels [30].



Iodine value

The iodine value (IV) of oils, expressed as milligrams of iodine absorbed per 100 grams of oil, provides crucial information about the degree of unsaturation in the fatty acids present. Higher IVs indicate oils with more unsaturated fatty acids, while lower values suggest oils with predominantly saturated or less unsaturated fatty acids. Coconut oil indicated low iodine value of 10.75 mg of iodine per 100 grams of oil. Similar report has been stated by [31] for iodine value of coconut oil which is within the range of 7.5 and 10.5 mg of iodine per 100 grams of oil. This indicates that coconut oil contains primarily saturated fatty acids, consistent with its known composition.

Ram oil, pork oil, groundnut oil, and fish oil, on the other hand, displayed significantly higher iodine values, reflecting their higher proportions of unsaturated fatty acids. Ram oil showed value of 60.00 mg of iodine per 100 grams of oil. Groundnut oil and fish oil exhibited iodine values of 161 mg/100g, and 65.50 mg/100g respectively. Pork oil showed the highest iodine value (200.50 mg of iodine per 100 grams of oil).

The high level of iodine value could be attributed to storage and processing methods especially when produced locally in unhygienic environment and the specie of the pig processed. The results in table 2 indicated variations in the unsaturation levels among the oils analyzed. More unsaturated fatty acids, including monounsaturated and polyunsaturated fats, are probably present in oils with higher iodine values, such as groundnut, fish, and pork oils [32]. Because they include higher amounts of unsaturated fats, which are linked to lower risks of cardiovascular diseases when ingested in moderation, these oils may have potential health benefits. Conversely, oils with lower iodine contents, such coconut oil, are mostly made up of saturated fats and may have various uses in cooking and nutrition. Identifying the

iodine values of oils is essential for a number of reasons, such as evaluating their possible health implications and establishing whether they are appropriate for particular culinary applications, such as baking and cooking. Because they contain unsaturated fats, oils with higher iodine contents may be more vulnerable to oxidation and rancidity, necessitating careful handling and storage to preserve freshness and quality. All things considered, the iodine readings offer insightful information about the makeup and properties of the examined oils, supporting both industrial and dietary uses.

Conclusion

In this study, a thorough grasp of the oils' composition, quality, and possible effects on industry and health is provided by the analysis carried out on the oils under investigation in this study. In order to lessen the negative cardiovascular effects, linked to the overall dietary fat composition of oil derived from animal oils, our findings emphasize the significance of including healthy oils in one's diet, with a focus on plant-based alternatives. The cholesterol content analysis showed significant differences between oils originating from plants, such as groundnut and coconut oil, which had negligible amounts of cholesterol, and oils derived from animals, such as fish and pork oil, which had greater levels. Groundnut oil, Ram oil, and fish oil showed better resistance to oxidation than coconut oil and pork oil, according to the peroxide values, which gave important information about the oils' oxidative stability. The evaluation of free fatty acid values demonstrated how important it is to keep an eye on the processing methods and hydrolysis levels in oils in order to preserve stability and quality; lower values are a sign of higher quality and longer shelf life. The highest saponification and lowest iodine value were found in coconut oil, indicating the presence of saturated fatty acids. The thorough examination of these oils improves our comprehension of their characteristics and

helps us make wise choices about their use and consumption in a variety of settings, such as industrial and food applications.

Availability of Data and Materials

The authors declare that all data discussed in the research work are available in the manuscript and will be made available on request. Contact Ifeoma Juliet Opara (the Corresponding authors) for the data availability on request.

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Conflicts of Interest

The authors declare no competing interests.

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