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RESEARCH ARTICLE

Comparative Analysis of Physicochemical Properties and Fatty Acid Profiles of Crude and Purified Oil from African Catfish (*Clarias gariepinus*)

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Abstract

The analysis of the physicochemical properties of oils obtained from aquatic sources helps to ascertain their qualities for use in the food and pharmaceutical industries. Fish oil, especially catfish oil, is gaining recognition due to its nutritional and therapeutic benefits. It is important to analyze the physicochemical properties of its crude and purified form for industrial application. Oil was extracted from African catfish (*Clarias gariepinus)*, and purified. The analysis of physical and chemical properties and fatty acid composition of both crude and purified oil was carried out and compared. The moisture content and iodine value of purified oil were significantly increased ($p<0.05$) by 80% and 79.9% respectively while a significant decrease in the free fatty acid (7.1%), unsaponifiable matters (99.1%), and melting point (76%) occurred in the purified oil. Specific gravity, peroxide value, acid value, saponification value, and refractive index of the refined oil were not significantly different from those of the crude oil. However, a significant decrease in the percentage composition of fatty acids (except saturated fatty acids) was observed in the purified oil compared to the crude oil. The polyunsaturated fatty acids composition, including omega-3 and omega-6, was higher in the crude oil compared to the purified oil. Based on our findings, increased moisture content and iodine values in purified oil make it unsuitable for food and industrial applications. A suitable extraction method is needed to regulate the moisture content and iodine values and also retain the polyunsaturated fatty acid composition after purification.

Keywords: *Clarias gariepinus, Catfish oil, physicochemical properties, fatty acid profile, polyunsaturated fatty acids.*

1. Introduction

The raising and breeding of many fish species, as well as other aquatic animals, for advanced scientific study, food, and adornment, is known as aquaculture. Due to its high protein, vitamin, and oil content, this area of agriculture has grown to be quite significant. According to (FAO, 2016), fish meal and fish oil are the most nutrient-dense and readily assimilated feed components for farmed fish, which is largely why aquacultures continue to use about 70% of the world's fish meal and fish oil production as feed (Tacon & Metian, 2015). Fish is abundant in fatty acids and protein, which offer nutrients and aid in curative processes for several health situations *(Abiona et al.,* 2021).

The analysis of the physicochemical characteristics of oils obtained from aquatic sources has become more important. This assists

in ensuring that these oils satisfy legal requirements, are uncontaminated, and have the appropriate qualities for a variety of uses in sectors ranging from food and medicines to cosmetics and environmental sustainability. Oils extracted from fish have recently become the subject of extensive research and are known to provide significant health benefits due to the presence of omega-3 polyunsaturated fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (Watanabe & Tatsuno, 2021). Catfish is a highly consumed fish species worldwide, and its oil is gaining recognition due to its potential nutritional and therapeutic properties (Pinho *et al.,* 2021; Wu & Bechtel, 2008). The polyunsaturated fatty acids (PUFAs) found in catfish oil, such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), have been linked to several health advantages (Effiong & Yaro, 2020). Numerous studies have demonstrated that fish oil helps reduce the risk of autoimmune illnesses, depression, hypertension, cardiac arrhythmias, diabetes, rheumatoid arthritis, photoreception (vision), and reproductive system problems (Douglas, 1992; Eslick *et al.,* 2009; Russell & Tisdale, 2005). Additionally, fish oil supports the healthy development of an infant's neurological system, including the brain and retina, especially in premature infants (Lapillonne & Jensen, 2009; Ma *et al.,* 2010). *Clarias gariepinus*, an African catfish, is an economically important species that is commonly cultured in Nigeria. It is a crucial catfish species for aquaculture and has a broad circulation across Africa (Niyibizi *et al.,* 2023).

Literature on comparison between the physicochemical properties of purified and unpurified catfish oil is scanty. This comparison is important for the industrial application of catfish oil to understand the advantages of purified oil against unpurified. Hence, the aim of the study was to compare the physicochemical characteristics and fatty acid composition of both purified and unpurified oils from catfish.

2. Materials and Methods

2.1. Fish collection and pre-processing

Catfish (*Clarias gariepinus*) were purchased at a local market in Badagry, Lagos State. The fish was washed thoroughly to remove dirt and kept in a freezer to preserve it before extraction. The fish was further dried using the oven and blended into a finer form with the use of mortar and pestle.

2.2. Catfish oil extraction

Using n-hexane as the solvent and a Soxhlet device, fish oil was extracted. In short, the weight of the combined fish sample was determined. It was then put in a cotton wool-covered thimble and put within the apparatus's inner tube. Next, a round-bottom flask with the appropriate size was fitted with the thimble to hold the solvent. The solvent was then heated for an hour. Boiling commenced and continued every two minutes for eighteen minutes before refluxing occurred. Following its use, the solvent was heated back to its original state and collected above the flask with a circular bottom, where it was placed into the Soxhlet apparatus to collect and measure the extracted oil.

2.3. Oil purification

50g of activated charcoal was added to a beaker containing 250ml of the crude fish oil to eliminate any undesirable colors or smells. The resulting mixture was stirred continuously for 5 minutes and a highly volatile solvent (methanol) of about 100ml was added. The solution was stirred again to maintain homogeneity and heated at 75°C on a heating mantle for 30 minutes. During heating, the solution was simultaneously stirred until it was hot and visibly boiling. The solution was allowed

to cool and a piece of muslin cloth was used to filter out the activated charcoal. Further filtration was carried out with a Whatman filter paper to obtain decolorized and deodorized fish oil.

2.4. Physico-chemical Properties

2.4.1. Physical properties

2.4.1.1. Relative Density

When oil's weight is compared to that of an equivalent volume of water at the same temperature, it can be claimed that the relative density of oils is being measured. In this study, relative density was measured using the bottle-type approach (Ndidiamaka & Ifeanyi, 2018). Ten milliliters of oil were put into a density bottle, which was first weighed and subsequently weighed with its contents.

Next, the relative density was computed using the formula below

Density = mass/volume

Relative density = density of sample/density of water.

2.4.1.2. Melting Point

The temperature where oil begins to melt is known as the melting point. This number indicates the types of fatty acids included in triglycerides. Low molecular weight and unsaturated fatty acids have low melting temperatures, whereas large molecular weight and saturated fatty acids have high melting points. Using the method used by Ndidiamaka & Ifeanyi (2018), 10 milliliters of oil was poured into a beaker and freeze. A thermometer was then inserted into the beaker and oil was heated. The temperature at which the oil began to melt was recorded.

2.4.1.3. Refractive Index

The angle at which light is bent when it passes through a small layer of melted fat is known as the refractive index, and it is one of the physical characteristics of triglycerides. A typical fat's refractive index is determined by both its degree of unsaturation and glyceride structure. When fatty acids are unsaturated, their molecular weight causes the refractive index to decrease, and *vice versa*. In measuring the refractive index of extracted catfish oils, three oil sample droplets were positioned on the polished portion of the refractometer's lower prism. Lowering the upper prism revealed a little layer of oil caught between the prisms. Above the surface, the prism shutter was open. The knobs for adjustment and the setting control were turned until the light boundary was sharply broken when peering through the telescope. The boundary was moved to match up exactly with the cross-wire intersection. The refractive index was calculated by opening the circular shutter located on the left, which illuminated the scale. It was also noted what temperature was used to measure the refractive index (Ndidiamaka & Ifeanyi, 2018).

2.4.2. Chemical Properties

2.4.2.1. Iodine Value

The term "iodine value" refers to how much iodine is absorbed by 100 grams of fat or oil. The amount of absorbed iodine serves as a gauge for the oil or fat's unsaturation. Additionally, the oil or fat's propensity to oxidize and turn rancid increases with its degree of unsaturation, or higher iodine value.

The iodine value of the crude and pure catfish oils were determined by using the AOAC official method (AOAC, 2000). One milligram of oil was weighed and placed in a 250-milliliter conical flask along with ten milliliters of carbon

tetrachloride. 13 milliliters of Wij's solution were added to the mixture. After stopping, shaking, and letting the flask stand in the dark for an hour, 10 milliliters of a 15% potassium iodide solution and 50 millimeters of water were added to it. After vigorously shaking the released iodide solution, a standard thiosulphate solution was added and titrated. Up to the point that the blue color vanished, starch was utilized as an indication. With no oil and in identical circumstances, a blank test was conducted. The value of iodine was computed using the formula:

Iodine value (mg) = $12.69 \times M \times (V_b V_a)/W$)

Where V_b= Volume of standard $Na_2S_2O_3$ solution used for the blank test, V_a = Volume of standard $Na_2S_2O_3$ solution used for the test sample, M = Molarity of $Na_2S_2O_3$, and W = Weight of oil sample (gram).

2.4.2.2. Free Fatty Acid Value

An oil's fatty acid value can be expressed as the amount of potassium hydroxide milligrams needed to neutralize one gram of free acid in the sample. The outcome is frequently given as the free acidity percentage. The acid value is a measurement of how much lipase action has broken down the glyceride in the oil. Since the synthesis of free fatty acids is typically accompanied by rancidity, the assessment is frequently employed as a broad indicator of the state and edibility of the oil, which also indicates the fat's age and quality. The AOAC official method (AOAC, 2000) was used to measure the fatty acid value, two grams of oil were weighed and placed in a 250-milliliter conical flask along with 100 milliliters of 95% ethanol that had been neutralized with two millimeters of phenolphthalein indicator. Until the oil was dissolved in the solvent, the conical flask was submerged in a hot water bath. 0.1mole KOH was added to the hot solution to titrate it until a pink tint developed that lasted for roughly ten seconds. The formula below was employed to compute the fatty acid value.

Acid value (milligram) = $56.1 \times M \times V/W$

Where V= titer value, M= molarity of KOH used, and W= weight in grams, of sample

2.4.2.3. Peroxide value

An indicator of the number of peroxides in oil resulting from oxygen uptake is the peroxide value. The taste and smell of rancid fats are not directly caused by peroxides, but the peroxide value, which indicates the concentration of peroxides, is frequently helpful in determining the degree of spoiling in the initial stages of food. A fat system's peroxide value loses reliability when oxidation is well underway because shorter chained products are beginning to break down. To measure the peroxide value of the extracted catfish oils, the AOAC official method (AOAC, 2000) was employed. One gram of liquid oil sample was weighed and then put into a clean, dry boiling tube. The liquid was then allowed to boil vigorously for thirty seconds, and after that, twenty millimeters of a solvent mixture (one volume glacial acetic acid plus one volume chloroform) and one gram of powdered potassium Iodide (KI) were added. A flask holding 20 milliliters of 5% KI solution was filled with the contents and was twice cleaned out with 25 milliliters of water. Starch was used as an indicator while titrating the mixture with 0.002 Mole sodium thiosulphate. With the same conditions, a blank test was also conducted concurrently. When reporting the peroxide value, the amount of sodium thiosulphate in milliliters per gram of material is commonly expressed as 0.0002 moles. The amount that results when multiplying this value by two is known as the milliequivalent of peroxide

oxygen per kilogram of the sample (meq/Kg), and it is a much more well-recognized measurement. To measure the peroxide value of the extracted oils, the following formula was adopted.

Peroxide value (millieq/kg) = T×M×100/Weight of sample

Where T = Titer value, and M = molarity of $Na_2S_2O_3$

2.4.2.4. Saponification Value

The quantity of potassium hydroxide milligrams needed to neutralize the fatty acids produced by fully hydrolyzing one gram of material is what is known as the saponification value. When saponification occurs, soap is created. To ensure that the saponification value of low molecular weight fatty acid esters is inversely related to the mean of the fatty acid weights in the glycerides present, additional alkali is needed. Thus, it is a measure of the typical molecular size of the fatty acids that are present.

The AOAC official method (AOAC, 2000) was used to determine the saponification value of the extracted catfish oil. One gram of oil sample was put into a 250-milliliter round-bottom flask. A small amount of boiling chips and 25 milliliters of 0.5mole ethanoic potassium hydroxide solution was added to the sample in the flask. After the flask was correctly fitted with a reflex tube to connect to a reflux condenser, it was linked to a water source. A heating mantle was used to apply heat, and after 30 minutes of refluxing, the heat source was turned off. A hot titration using 0.5 mole of HCl was conducted after adding 2 milliliters of 1% phenolphthalein solution (indicator) to the mixture. Concurrently, a blank test was administered in the same settings.

The saponification value is determined using the formula:

Saponification value (mg) = 56.1×M×(Va-Vb)/W

= 56.1 ×0.5×(Vb-Va)/1.0

Where 56.1 = molecular weight of KOH, M = molarity of the standardized HCl solution, Vb = volume of standardized HCl solution used for the blank, Va = Volume of standardized HCl solution used for the test sample, and W = Weight of sample, in grams.

2.4.2.5. Unsaponifiable value

A 250-ml flask with a reflux condenser was filled with around 5 grams of the material under investigation, which had been precisely weighed. After adding a solution containing two grams of potassium hydroxide in forty milliliters of 95% ethanol, the mixture was heated in a water bath for an hour while being shaken frequently. Then, using 100 ml of hot water as help, the contents of the flask were moved to a separating funnel. Three portions (each containing 100 ml of peroxide-free ether) were thoroughly shaken with the liquid while it was still warm. A second separating funnel holding 40 ml of water was used to mix the ether extracts. After giving it a gentle stir for a few minutes to allow the contents to separate, the bottom layer was thrown out. Two 40 ml volumes of water and three 40 ml parts of a 3 percent w/v potassium hydroxide solution were used to wash the extract. A 40 ml water wash was performed after each treatment. Ultimately, the ether layer was cleaned using 40 ml amounts of water at a time until the aqueous layer stopped being alkaline with the phenolphthalein solution. Using a mild air current, the solvent was completely extracted from the flask. After 30 minutes of drying at 100° to 105° in a desiccator,

the residue was weighed. The percentage of unsaponifiable materials based on weight was determined. Furthermore, the residue was titrated with 0.1 M ethanolic potassium hydroxide after being dissolved in 20 ml of 95% ethanol that had first been neutralized to a phenolphthalein solution. The test had to be redone if the volume of 0.1 M ethanolic potassium hydroxide was more than 0.2 ml because it was specified that the weighed amount could not be regarded as an unsaponifiable substance.

2.5. Determination of fatty acid composition

The extract was subjected to GC-MS analysis using an Agilent 5977B GC/MSD system in conjunction with an Agilent 8860 auto-sampler, a Gas Chromatograph interfaced to a Mass Spectrometer (GC-MS) fitted with an Elite-5MS (5% diphenyl/95% dimethyl polysiloxane) fused a capillary column (30 × 0.25µm ID × 0.25 µm df). A 70eV ionization energy was used in the electron impact mode of an electron ionization system for GC-MS detection. With a split ratio of 10:1, an injection volume of 1µl and helium gas (99.999%) was utilized as the carrier gas and flow rate, respectively, at a steady 1 ml/min. Utilizing the 40ppm stock solution, five-point serial dilution calibration standards (1.25, 2.5, 5.0, and 10.0 ppm) were made and utilized to calibrate the GC-MS. Temperatures were maintained at 300 °C for the injector, 250 °C for the ion source, and 100 °C (isothermal) for 0.5 min in the oven, with a 20 °C/min increase to 280 °C (2.5 min) for the oven. Mass spectra were obtained at 70 eV with a 0.5 s scanning interval and fragments ranging from 45 to 450 Da. GC/MS ran for a total of 21.33 minutes, with a solvent delay of 0 to 3 minutes.

2.6 Statistical analysis

Each experiment was carried out in triplicate and all data are presented as Mean ± SD. Statistical analysis was carried out using GraphPad Prism (version 10.0) software. Difference between means was compared using independent student t-test. $P<0.05$ was used as the threshold for significance.

3. Results

The physicochemical properties of both the purified and unpurified catfish oil are represented in Figure 1. A significant increase was observed in the moisture and volatile matter ($p<0.05$) and iodine values of the purified oil when compared to the crude fish oil. Following oil purification, the moisture content and volatile matter increased by 80%. Iodine value of the purified oil also considerably rose by 79.9% compared to the unpurified oil. Following purification, there were no appreciable variations in the oil's specific gravity, peroxide, acid, saponification values, and refractive index. However, there was a significant reduction ($p<0.05$) in the free fatty acid composition (7.1%) unsaponifiable matter (99.9%), and slip melting point (76%) of the catfish oil after purification.

Table 1 shows the fatty acid profile of crude and purified catfish oil. All saturated fatty acid content were significantly higher in the purified oil compared to the unpurified catfish oil among which heptadecanoic acid was the highest with 32.04%. Among the monounsaturated fatty acids, palmitoleic acid, an omega-7 fatty acid, was present in the highest concentration (22.04%) while the lowest was pentadecanoic acid with 0.17%. Palmitoleic acid composition in the purified oil was significantly increased while oleic acid was significantly reduced. In addition, the percentage composition of eicosenoic acid was significantly increased to 12.37% after purification. Total polyunsaturated fatty acid level was

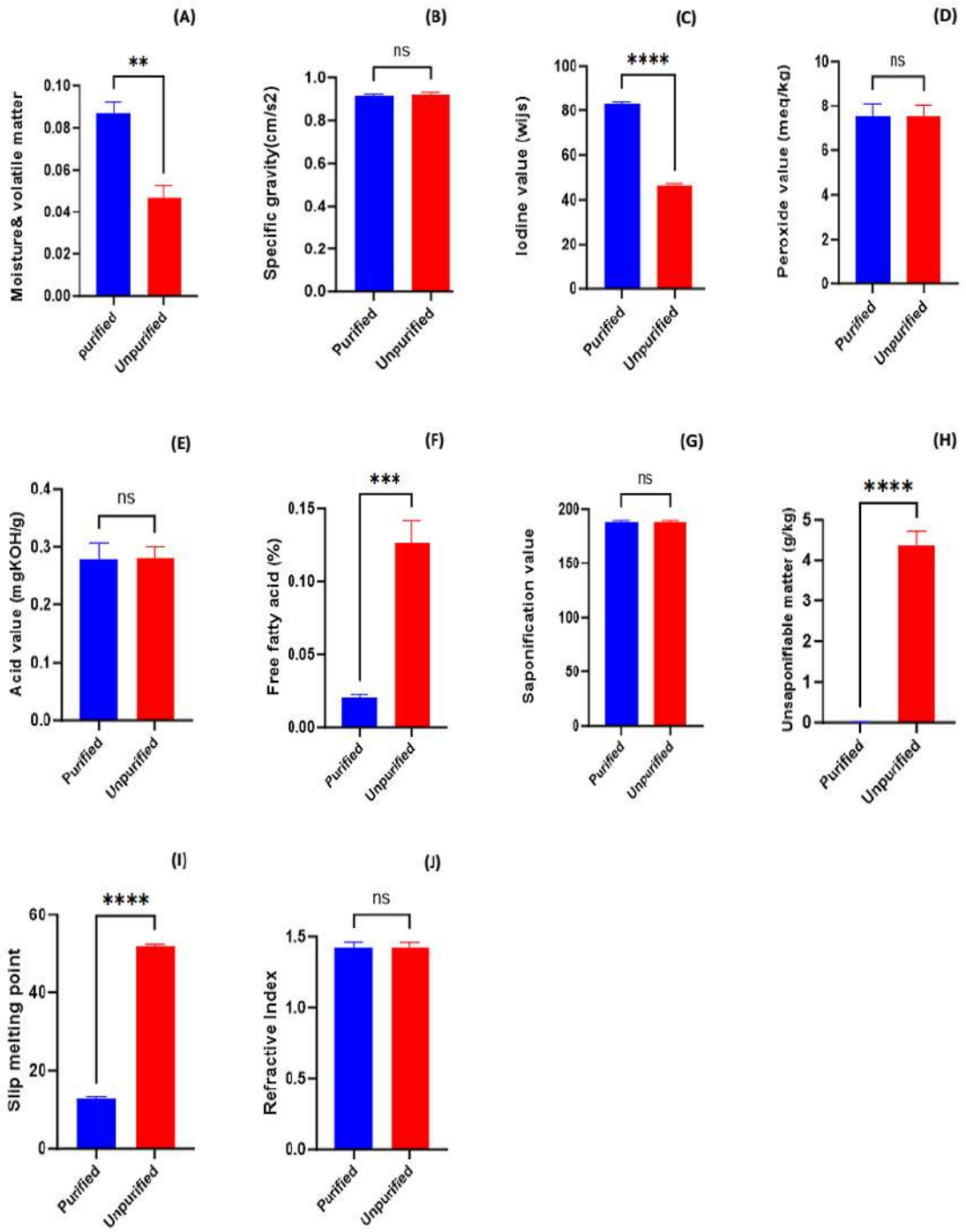

Figure 1 (A-J). Moisture and volatile matter (A), Specific gravity (B), Iodine value (C), Peroxide value (D), Acid value (E), Free fatty acid (F), Saponification value (G), Unsaponifiable matter (H), Slip melting point (I) and Refractive index (J) of purified and unpurified catfish oil. Each bar represents the mean ± SD. Bars with ns are not significantly different. Bars with *, **, ***, and **** are significantly different at P<0.05, 0.01, 0.001, and 0.0001 respectively

significantly reduced after oil purification from 46.22% - 19.62%. Linoleic acid significantly reduced from 33.63% to 12.48% after oil purification. A similar percentage decrease was observed in gamma-linolenic acid from 5.98% to 2.41% in the purified oil. Eicosatrienoic acid decreased from 1.88% to 0.75%, however, its isomer, C20:3 *Cis*-8, 11, 14, was significantly increased from 0.001% to 0.66% in the purified oil.

Table 1. Fatty acid profile of unpurified and purified catfish o

Fatty acid composition	Unpurified (%)	Purified (%)
Saturated fatty acids		
C12:0	<0.001	1.01
C16:0	6.63	18.89
C17:0	<0.001	32.04
C18:0	0.26	1.13
C20:0	<0.001	24.78
C21:0	0.61	1.46
C24:0	<0.001	1.85
∑SFA	7.50	81.16
Monounsaturated fatty acids		
C14:1 Cis-9	<0.001	1.71
C15:1 Cis-10	<0.001	0.17
C16:1 Cis-9	8.79	22.04
C18:1 Trans-9	0.51	3.47
C18:1 Cis-9	34.52	2.10
C20:1 Cis-11	<0.001	12.37
∑MUFA	43.82	41.86
Polyunsaturated fatty acids		
C18:2 Cis-9,12	33.63	12.48
C18:3 Cis-6,9,12	5.98	2.41
C20:2 Cis-11,14	4.73	3.32
C20:3 Cis-8,11,14	<0.001	0.66
C20:3 Cis-11, 14,17	1.88	0.75
∑PUFA	46.22	19.62

4. Discussion

Catfish oil is gaining high attention in research due to its high composition of polyunsaturated fatty acids (PUFAs), including eicosatrienoic acid (ETA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), that are very beneficial to human health (Effiong & Yaro, 2020). In addition to lowering blood pressure and the risk of death in those with cardiovascular disease, PUFA consumption has been linked to a reduction in plasma cholesterol, triacylglycerols (TAG), inflammatory cytokines, chemo-attractants, cell adhesion molecules, and eicosanoids (Amri *et al.*, 2021). However, there is a need to understand its quality and stability which are key factors in the industrial application of this oil.

We examined the chemical and physical characteristics of catfish oil in this investigation and contrasted the unpurified and purified oils' respective characteristics. Our study revealed a slight increase in the moisture content and volatile matter of the purified oil. The increase in volatile matter might be a result of the addition of a highly volatile solvent (methanol) to the crude oil during the purification process and this might also account for the increase in the moisture content. High moisture content in catfish makes it prone to spoilage by microbes (Sutikno *et al.*, 2019). Interestingly, Gaydaybul *et al.* (2020) indicated that fish with higher moisture content contain more quantity of oil, and this is a reflection of more oil content in fish. No significant increase in specific gravity was observed in the purified catfish oil compared to the unpurified oil. Our study revealed a specific gravity of 0.91 which aligns with the result of Anah *et al.* (2021). The specific gravity of a substance is its density divided by the density of an equivalent volume of water. It is important in the quality assessment of oil as it helps determine how dense (heavy) the oil is when compared to water. The oil's chemical makeup has an impact on specific gravity. The specific gravity of the oil rises with an increase in the amount of aromatic compounds and

decreases with an increase in the amount of saturated compounds (Abu-Elella *et al.,* 2015).

Our study revealed a significant increase in the iodine value of purified oil compared to the unpurified. The iodine values reported in this study were 83.77 I_2/100g and 46.57 I_2/100g in purified and unpurified catfish oil respectively. This increase in iodine values aligns with the findings of Amri *et al.* (2021) where the iodine values were reported to be 83.94 g I_2/100g and 87.65 g I_2/100g before purification and after purification respectively. Our findings is also similar to that of Abiona *et al.* (2021) where iodine value of 85.20 was reported in oil extracted from catfish gills before purification. Catfish oil contains unsaturated fatty acids, as indicated in Table 1, and the quantity of iodine attached to these fatty acids reveals the number of double bonds in the oil (Amri *et al.,* 2021).

No difference was observed in the peroxide values of both the purified and the unpurified catfish oil in this study. This finding contradicts the findings of Amri *et al.* (2021) where a significant decrease in the peroxide values was reported in the purified oil compared to the crude catfish oil, having values of 8.77 (meq/kg) and 4.39 (meq/kg) in crude and purified catfish oils respectively. This difference might results from different purification method, fish species and parts, and extraction temperature employed in their studies. Amri *et al.* (2021) used bentonite absorbent and activated charcoal at 70°C while we only used activated charcoal and a heating temperature at 75°C. The peroxide values of catfish oil in our study are also greater than previously published values in Abiona *et al.,* (2021) (2.60meq/kg) (from gills of *Clarias macrocephalus)* and Ningrum et al., (2023) (5.15meq/kg) (from head of *Clarias gariepinus*). These differences might be a result of differences in fish species and parts, and extraction methods. The acid values and free fatty acid values reported in this study showed no significant differences before and after the purification of catfish oil. However, these values are much lower than the acid values and free fatty acid values reported by previous studies (Abiona *et al.*, 2021; Amri *et al.*, 2021; Anah *et al.*, 2021). Again, these differences might result from different extraction temperatures and different parts of the fish employed compared to our study where the oils were extracted from the gills.

Contrary to the findings of Amri *et al.*, 2021 our study showed no changes in the saponification values of catfish oil before and after purification. However, the saponification values reported in this study are within the range reported by previous studies (Abiona *et al.*, 2021; Amri *et al.,* 2021; Anah *et al.,* 2021; Ningrum *et al.*, 2023). The amount of KOH milligrams needed to completely hydrolyze 1.0 g of the material and yield the fatty acids is known as the saponification value (together with the free fatty acids already present in the oil). It is therefore a measure of the total acids present and indicates purity (Anah et al., 2021). The unsaponifiable matter, on the other hand, was drastically reduced from 4.6 to 0.0001 after oil purification was performed. A measurement of the water-soluble component that is created after heating oil with potassium hydroxide is called unsaponifiable matter content. When making soap, the quality of the oil plays a crucial role. The high amount of unsaponifiable matter is indicative of contamination or adulteration with mineral oils (Onwuliri *et al.,* 2011). Based on this fact, our study demonstrated that oil purification is of more benefit in removing unsaponifiable matters. Our study also observed a significant decrease in the slip melting point of the purified oil compared with the crude catfish oil.

This observed difference makes the purified oil more suitable for industrial applications.

The temperature at which oil begins to melt is known as the melting point, and it can be used to determine the types of fatty acids present in triglycerides. Our study showed the highest percentage composition in the saturated fatty acids compared to the monounsaturated and polyunsaturated fatty acids. This aligns with the findings of Abiona *et al.* (2021) where saturated fatty acid composition was observed to be highest among the fatty acids identified in the oil extracted from the catfish gills. These fatty acids were observed to significantly increase in percentage composition after oil purification as shown in our study.

The effect of temperature during oil purification contributes to the high percentage increase in saturated fatty acid composition (Zhuang *et al.,* 2022). However, contrary to the study of Abiona *et al.* (2021) and Ningrum *et al.* (2023) where palmitic acid was reported to be highest among saturated fatty acids, our study showed heptadecanoic acid as the highest saturated fatty acid in the purified catfish oil. The percentage composition of monounsaturated fatty acids observed in this study (41-43%) closely aligns with the one reported by Abiona *et al.,* 2021 (40.7%), Ningrum *et al.*, 2023 (43-44%), Gebremichael *et al.*, 2023 (38%). The total polyunsaturated fatty acid percentage composition of 46.22% and 19.2% in unpurified and purified oil respectively, were greater than the one reported by previous studies. Gebremichael *et al.* (2023) reported total polyunsaturated fatty acid to be 27.7% while 17.68% and 13.51% were reported by Karina *et al.* (2023) and Abiona *et al.* (2021) respectively.

Our study demonstrated a high content of omega-3 and omega-6 fatty acids among the polyunsaturated fatty acid in the catfish oil. A high content of eicosatrienoic acid (C20:3 cis 8,11,14), an omega-3 fatty acid, was observed in catfish oil, which was however decreased in the purified oil. Concentration of Omega-6 fatty acids including linoleic acid (C18:2 cis 9,12), gamma-linolenic acid (C18:3 cis 6,9,12), and eicosadienoic acid acid (C20:2 cis 11,14) were also reduced after oil purification. These findings align with that of Amri *et al.* (2021) where a similar percentage decrease was observed in refined catfish oil compared to crude catfish oil. This decrease in polyunsaturated fatty acids results from the effect of temperature applied during the purification process since polyunsaturated fatty acids are chemically unstable during thermal processing (Zhuang *et al.,* 2022). The ratio of polyunsaturated fatty to saturated fatty acids in our study is 6.1 and 4.1 in unpurified and purified catfish oil respectively. These are within the recommended ratio (higher than 0.4) in animal products to reduce the risk of cardiovascular, autoimmune, and other chronic diseases (Gebremichael *et al.*, 2023).

5. Conclusion

Our study showed a significant difference in some physicochemical properties including specific gravity, peroxide value, acid value, saponification value, refractive index, and fatty acid composition of both forms of oil (crude and purified) extracted from *Clarias gariepinus* (Catfish). However, these characteristics fall within the recommended and reveal the potential of Catfish oil as a valuable source of nutrients and energy suitable for human consumption. However, the high increase in moisture content and iodine value of the purified oil call for serious attention. High moisture content makes oil prone to microbial damage while increased iodine values reduce the oxidative storage stability of oil. These properties make purified oil unsuitable for food and industrial

applications. Also, the polyunsaturated fatty acids (especially omega-3 and omega-6) composition of *Clarias gariepinus* oil as demonstrated in this study, makes the oil fit for usage in the food sector due to the health benefits of polyunsaturated fatty acids. However, the significant decrease in the composition of polyunsaturated fatty acids in purified oil calls for a need to develop effective purification methods that could retain or minimally reduce the polyunsaturated fatty acid composition of Catfish oil.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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