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Characterization of Oil from Trunk Fish (*Moryrus Rume*)

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Abstract
Fish is an important source of food that provide high protein content and essential amino acids to the body. Fish oil produced internationally (marine fish) are expensive to procure and occasionally unavailable. However, expression of oil from freshwater fish species will provide cheap, abundant and readily available product. This study therefore, aimed at the expression of fish oil from *Mormyrus rume*. A total of 10kg of *Mormyrus rume* was procured from Kainji Lake Basin, New Bussa Niger State. The fish were divided into three samples 1, 2 and 3 respectively. Sample 1 was pre-heated for a period of 10 minutes, at maximum temperature of 90^0C, sample 2 for 15 minutes at a maximum temperature of 100^0C and sample 3 for 20 minutes at maximum of 100^0C. After pre-heating, samples were immediately transferred to laboratory for oil expression using a continues mechanical extruder. The characterization of the expressed fish oil was measured using the specific gravity, saponification value and free fatty acid value. Results showed that the fish oil from samples 1, 2, and 3 had specific gravity of 0.910, 0.907 and 0.909 respectively, the saponification value of 122.110mg/KOH/g, 124.582mg/KOH/g and 123.102mg/KOH/g respectively while the free fatty acid value was found to be 1.286% for sample 1, 1.342% for sample 2, and sample 3, 1.401. It is observed that the fish oil values ware within the acceptable standard value which are suitable for application in pharmaceutical and food industries. Therefore, *Moryrus rume* has the potential of producing fish oil for industrial and domestic use.

Keywords: *Mormyrus rume*, extruder, fish oil, characterization, free fatty acid value.

1. Introduction
Fish oil is distinguished from many other dietary fats by its unique composition of long-chain polyunsaturated fatty acids (PUFAs), particularly the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are essential for human health. EPA and DHA are mostly found in oily fish and fish oils and contribute to the fluidity and function of cell membranes throughout the body, especially in cardiac and neural tissues. These fatty acids play important roles in modulating inflammation, lipid metabolism, and vascular function, and cannot be synthesized efficiently by the human body, making dietary intake critical for maintaining physiological balance.

Epidemiological and clinical evidence suggests that regular consumption of EPA and DHA either through dietary fish or fish oil supplementation can provide significant cardiovascular benefits. These include lowering plasma triglycerides, reducing the risk of fatal arrhythmias, improving endothelial function, and decreasing markers of systemic inflammation associated with coronary artery disease and heart failure. Additionally, higher intakes of omega-3 PUFAs have been linked to modest reductions in blood pressure and may contribute to cardiac remodelling benefits in specific patient groups. Although some large clinical trials show variable results regarding mortality benefits, evidence supports the inclusion of fish oil or oily fish in a heart-healthy diet.

Beyond cardiovascular effects, omega-3 fatty acids also play roles in brain health and mood regulation, as well as in reducing systemic inflammation linked to conditions such as rheumatoid arthritis, asthma, and inflammatory bowel disease. A balanced intake of EPA and DHA has been associated with neurodevelopmental support, cognitive performance,

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and reduced depressive symptoms in some clinical studies [17].

Fish itself is not only a source of beneficial oils but also a high-quality source of complete protein and key micronutrients such as calcium, phosphorus, selenium, and vitamin D, making it an important component of nutritionally balanced diets worldwide [9]. Fish consumption is widely accepted across cultures and often more cost-effective than other animal protein sources [14]. These nutritional attributes, along with the growing recognition of fish oil's health benefits, have stimulated research into the exploitation of diverse fish species for oil production, including those that are small, unmarketable, or prone to rapid spoilage.

Fish oil is defined as the lipid fraction extracted from fish flesh, by-products, and viscera, and can be produced from both marine species (e.g., mackerel, tuna, salmon) and freshwater species (e.g., *Mormyrus rume*, *Clarias gariepinus*). While marine fish oils have traditionally been the major commercial source of EPA and DHA due to their high concentrations of long-chain PUFAs, studies indicate that certain freshwater species also contain substantial quantities of these essential fatty acids, suggesting they may be viable local resources for oil extraction and utilization [13, 29].

The increasing global demand for high-quality omega-3 fatty acids for nutritional and therapeutic applications highlights the need to explore alternative fish sources [25]. This study was therefore aimed at the extraction and characterization of fish oil from the local freshwater species *Mormyrus rume* to assess its potential as a dietary and industrial lipid resource.

2. Materials and Methods

This study was conducted in the Product Development and Engineering Department of the National Institute for Freshwater Fisheries Research, New Bussa, Niger State, Nigeria. A total of 1,000 g of *Mormyrus rume* was obtained from the Kainji Lake Basin, Niger State, Nigeria. The fish samples were immediately placed in an insulated ice box to maintain freshness during transportation to the laboratory, following standard sample handling procedures to minimize biochemical changes prior to analysis [11].

Upon arrival at the laboratory, the fish were eviscerated and de-finned, then thoroughly rinsed with potable water to remove slime, blood, and surface contaminants. The cleaned fish samples were transferred into clean stainless-steel bowls and prepared for pre-heating and subsequent oil extraction.

2.1. Pre-Heating of Fish Samples

Pre-heating of fish tissue prior to oil expression influences oil yield, quality, and physicochemical properties such as specific gravity, saponification value, and free fatty acid content [28]. To evaluate the effects of varying pre-heating conditions, the cleaned fish samples were divided into three equal portions of 330 g each**,** labeled Sample 1, Sample 2, and Sample 3**.**

Each sample was subjected to pre-heating in a calibrated electric oven (Model: XYZ-150, ±2°C accuracy):
Sample 1: 10 minutes at 90°C
Sample 2: 15 minutes at 100°C
Sample 3: 20 minutes at 100°C
After heating, each sample was cooled to room temperature and immediately transferred for oil expression to prevent oxidative degradation of lipids [2].

2.2. Oil Expression Method

Oil extraction was performed using a continuous mechanical extruder designed for small-scale oily seed/biomass oil expression (modified screw press). The extruder was pre-warmed and calibrated according to manufacturer guidelines to ensure consistent operation. Each 330 g pre-heated fish sample was fed into the extruder's hopper at a steady rate. The screw shaft conveyed, crushed, and compressed the sample to express the oil through pressure and shear forces, similar to methods used in plant-based oil extraction studies [7, 23] and adapted for fish tissue.

The extruder was selected based on its demonstrated higher efficiency in preliminary trials compared with earlier models, showing improved oil recovery and reduced residual oil in the press cake.

During each extraction run, the expressed oil and the solid residue (fish cake) were collected separately into pre-weighed containers. Each extraction trial was replicated three times to ensure data reliability. After each run, the expressed oil and residue were weighed using a precision electronic balance (±0.01 g), and average values were recorded.

From the mass measurements, oil yield and expression efficiency of the extruder were calculated as follows:

$$\% \text{ Oil yield} = \frac{weight\ of\ Oil}{weight\ of\ expressed Oil} \times 100 \quad (1)$$

$$\% \text{ Expression Efficiency} = \frac{Oil\ yield}{Total\ Oil\ content} \times 100 \quad (2)$$

Calculations were performed according to established extraction efficiency models [21, 28].

Figure 1. Extruder used for oil expression

2.3. Characterization of the Expressed Fish Oil

The characterization of the expressed fish oil was carried out at the Central Laboratory of the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Niger State, Nigeria**,** to determine its specific gravity, saponification value, and free fatty acid (FFA) content**.** These parameters are commonly used to evaluate the quality, purity, and suitability of fish oils for food, pharmaceutical, and industrial applications [3, 6].

2.3.1. Determination of Specific Gravity (SG)

Specific gravity was determined using a 30 mL density bottle (pycnometer) following standard analytical procedures [4, 26]. The clean, dry bottle was first weighed empty (W_0), then filled with fish oil, stoppered, and reweighed (W_1). After washing and drying, the bottle was filled with distilled water and weighed again (W_2). Each measurement was performed in triplicate.

The specific gravity of the oil was calculated using Equation (3):

$$\text{Specific gravity} = \frac{W_1 - W_o}{W_2 - W_o} = \frac{Mass\ of\ the\ substance}{Mass\ of\ equal\ volume\ of\ water} \quad (3)$$

Specific gravity is an important indicator of oil purity and composition and reflects the molecular weight and degree of unsaturation of fatty acids in fish oil [3].

2.3.2. Determination of Saponification Value (SV)

The saponification value (SV) was determined according to the AOCS official method [4] with minor

modifications in line with recent fish oil quality studies [1]. A 5 g oil sample was dissolved in 15 mL of 1.0 N ethanolic potassium hydroxide (KOH) and refluxed for 25–35 minutes until complete saponification was achieved. After cooling, phenolphthalein indicator was added, and the mixture was titrated with 0.5 N hydrochloric acid (HCl) until a faint pink endpoint disappeared. A blank titration was also conducted without oil.

The saponification value was calculated using Equation (4) [3].

$$\text{Saponification value (SV)} = \frac{56.1(a-b)\times N}{weight\ of\ Oil\ sample} \quad (4)$$

where, a = Volume (mL) of 0.5 mol L-1 hydrochloric acid consumed in the blank test;

b = Volume (mL) of 0.5 mol L-1 hydrochloric acid consumed in the test;

N = Normality of hydrochloric acid;

W = Weight of oil sample, (g).

Saponification value reflects the average molecular weight of fatty acids in the oil and is useful for assessing its suitability for edible and industrial applications (Odetoye *et al.*, 2024).

2.3.3. Determination of Free Fatty Acid (FFA)

The free fatty acid (FFA) content of the oil was determined using the AOCS method [4, 5, 6] as described by Laila *et al* [16] and updated by Rahman *et al* [28]. A 5 g oil sample was mixed with 50 mL of 50% neutralized ethanol and shaken thoroughly. Phenolphthalein indicator was added, and the mixture was titrated with 0.1 N sodium hydroxide (NaOH) until a persistent light pink colour was observed.

The percentage FFA was calculated using Equation (5):

$$\%\ \text{FFA value} = \frac{Alkali\ volume\ (mL) \times Alkali\ normality\ 28.3}{Sample\ weight\ (g)} \quad (5)$$

FFA content is a critical indicator of oil freshness and hydrolytic rancidity; lower values indicate better oil stability and suitability for human consumption [3, 1].

2.4. Statistical Analysis

Data obtained from the oil extraction and quality analysis were subjected to one-way analysis of variance (ANOVA) to determine the effects of pre-heating temperature and time on oil yield and quality parameters. Statistical analysis was performed using Design-Expert software (Version 13.0, Stat-Ease Inc., USA). Differences among means were considered significant at $p < 0.05$, consistent with standard analytical practice in food and lipid research [18, 21, 34].

3. Results and Discussion

Table 1 presents the results of oil yield and physicochemical properties of the expressed fish oil, while Tables 2, 3, 4, and 5 show the ANOVA results for specific gravity, saponification value, free fatty acid content, and oil yield, respectively. The results indicate that differences in specific gravity, saponification value, and free fatty acid content among the samples were not statistically significant ($p > 0.05$). However, pre-heating temperature significantly affected oil yield ($p < 0.05$), indicating that thermal treatment plays a crucial role in enhancing oil release from fish tissue. This observation agrees with recent findings that moderate thermal pre-treatment improves lipid cell rupture and oil recovery in fish oil extraction [28, 21, 32].

Table 1. Result on Characterization of *Mormyrus rume* Fish Oil

Process Parameter	1	2	3
Specific gravity	0.910	0.907	0.909
Saponification value (mgKOH g^{-1})	122.110	124.582	123.102
Free fatty acid value (%)	1.286	1.1342	3.1401
Temperature (^{0}C)	80	90	100
Time (minute)	10	15	20
Oil yield (%)	21.2	24.6	23.5
Expression efficiency	64	71	69

Table 2. ANOVE Table for Specific Gravity

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	0.0002	2	0.0001	3.30	0.1745	not significant
Temperature	0.0001	1	0.0001	4.98	0.1117	
Heating Time	0.0000	1	0.0000	1.62	0.2927	
Residual	0.0001	3	0.0000			
Lack of Fit	0.0001	2	0.0000	9.29	0.2260	not significant
Pure Error	4.500E-06	1	4.500E-06			
Cor Total	0.0003	5				

R-Squared = 0.6877

Table 3. ANOVE Table for Saponification Value

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	8.51	2	4.26	2.62	0.220	not significant
Temperature	2.27	1	2.27	1.39	0.322	
Heating Time	6.24	1	6.24	3.84	0.145	
Residual	4.88	3	1.63			
Lack of Fit	4.82	2	2.41	41.2	0.1094	not significant
Pure Error	0.0585	1	0.058			
Cor Total	13.39	5				

R-Squared = 0.6355

Table 4. ANOVE Table for Free fatty Acid Value

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	3.14	2	1.57	3.47	0.1658	not significant
Temperature	0.0070	1	0.0070	0.0155	0.9088	
Heating Time	3.13	1	3.13	6.93	0.0782	
Residual	1.36	3	0.4525			
Lack of Fit	1.36	2	0.6781	507.41	0.0314	significant
Pure Error	0.0013	1	0.0013			
Cor Total	4.50	5				

R-Squared = 0.6982

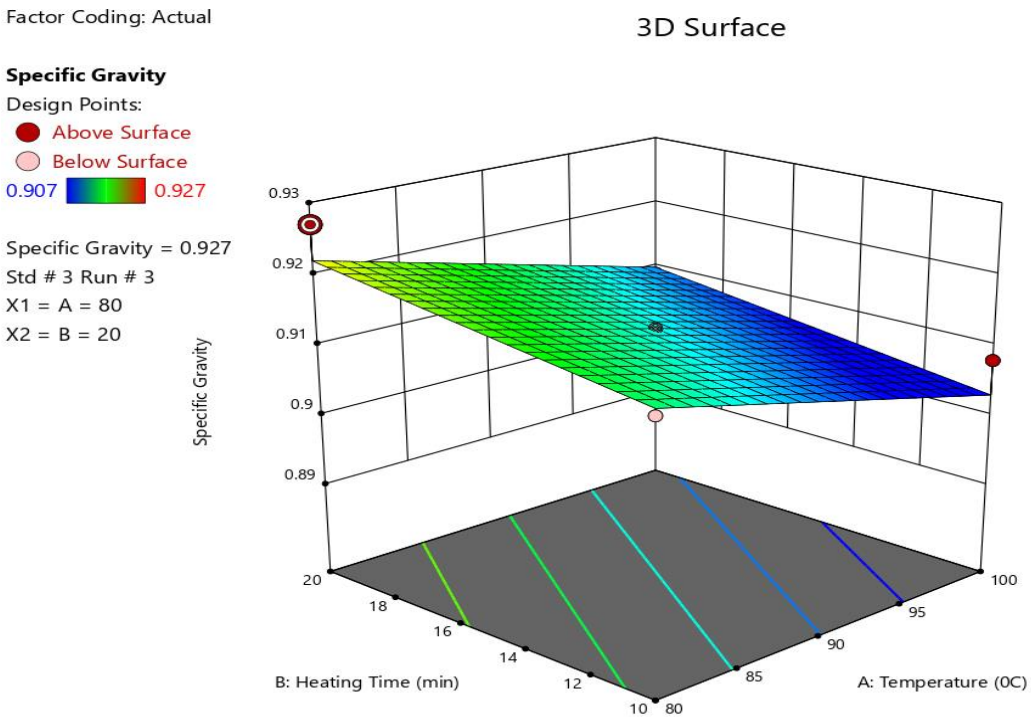

Figure 1. Surface plot of temperature and heating time interactions on specific gravity

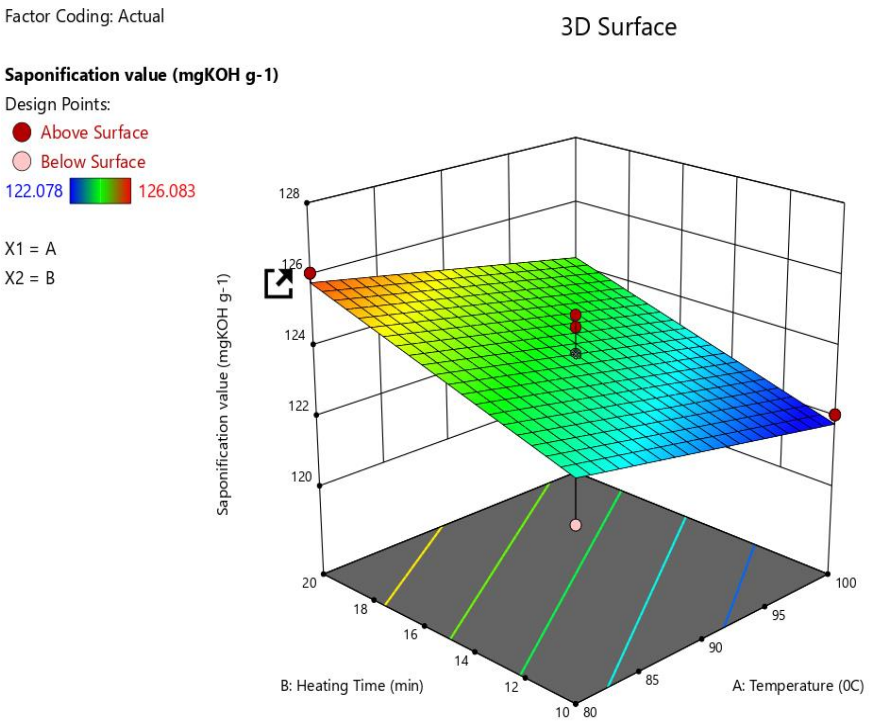

Figure 2. Surface plot of temperature and heating time interactions on saponification value

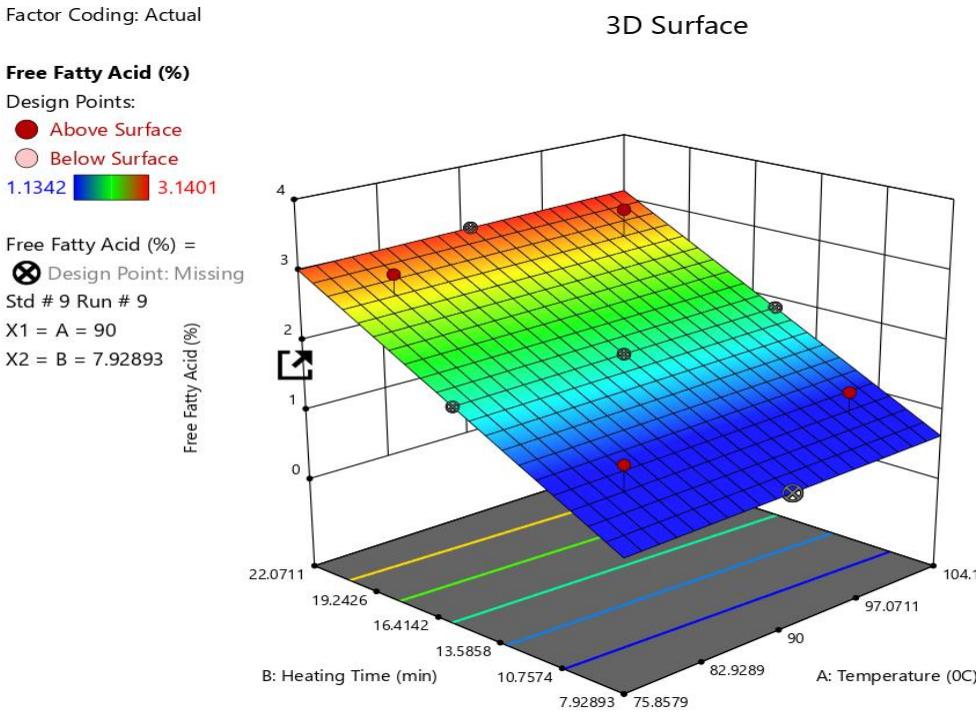

Figure 3. Surface plot of temperature and heating time interactions on free fatty acid

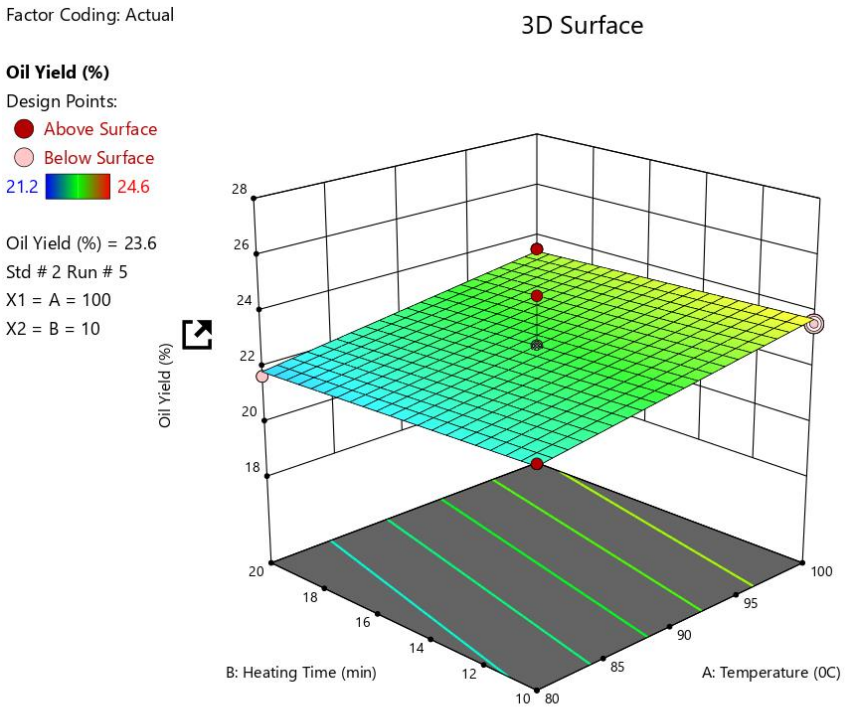

Figure 4. Surface plot of temperature and heating time interactions on oil yield

Figure 1-4: Show response surface plots for the effect of input variables (temperature and heating time) on oil quality parameters (specific gravity, saponification value and free fatty acid) and oil yield.

Figure 1, 2 and 3 show that as the temperature and heating time increase the specific gravity, saponification values and free fatty acid increased. This agrees with the findings of Oluwole *et al.,* [24] and Bello *et al.,* [10].

Table 1 showed that Sample 1 had specific gravity 0.910, sample 2, 122.110 and sample 3, 1.286 mg/KOH. These values are in agreement with the results on *Mormyrus rume* oil when compared with the standard value of ASTM which was found to be 0.907 – 0.915, 120 – 175mg/KOH and 1-7 %. The saponification value of sample 1 was 122.110mg/KOHg^{-1}, sample 2, 124.582mg/KOHg^{-1}, and sample 3 was 123.102mg/KOHg^{-1}. These values were also within the standard value for fish oil obtained from ASTM (120 -175 mg/KOHg^{-1}). The free fatty acid was found to be 1.286% for sample 1, while sample 2, and 3 had 1.1342% and 3.1401%. Tables 2, 3, 4 and 5 show that the observed specific gravity, saponification values, free fatty acid of the oils were not significantly different. Table 5, however, shows that the observed differences in oil yield were also not significant. This agrees with the finding of Bello *et al.* [10, 18].

Table 5. ANOVE Table for Oil Yield

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	2.53	2	1.26	0.6460	0.5844	not significant
Temperature	2.40	1	2.40	1.23	0.3484	
Heating Time	0.1225	1	0.1225	0.0627	0.8185	
Residual	5.86	3	1.95			
Lack of Fit	0.0833	2	0.0417	0.0072	0.9929	not significant
Pure Error	5.78	1	5.78			
Cor Total	8.39	5				

R-Squared = 0.8010

4. Conclusions

This study evaluated the quality and yield of oil expressed from *Mormyrus rume* subjected to different pre-heating conditions and extracted using a mechanical extruder. The findings demonstrate the suitability of *Mormyrus rume* as a viable freshwater source of fish oil for both domestic and industrial applications.

(i) The physicochemical characterization of the expressed oil revealed that the specific gravity, saponification value, and free fatty acid (FFA) content of all samples were within internationally recommended standard ranges. The specific gravity values fell within 0.907–0.915, indicating appropriate oil density and purity. Similarly, the saponification values were within 120–175 mg KOH/g, reflecting the presence of fatty acids with suitable molecular weights for nutritional and industrial use. The free fatty acid values, which ranged between 1–7%**,** suggest minimal hydrolytic degradation and good oil stability, confirming the freshness and acceptable quality of the extracted oil.

(ii) Based on these quality parameters, the oil extracted from *Mormyrus rume* is considered suitable for application in the food and pharmaceutical industries. Its acceptable free fatty acid content and saponification value indicate potential for use in edible oil formulations, nutraceutical products, and as a raw material in pharmaceutical preparations where lipid quality and stability are critical.

(iii) The results further indicate that pre-heating time and temperature significantly influenced oil yield**,** with increased heating enhancing oil expression efficiency by facilitating tissue breakdown and oil release. Importantly, these thermal pre-treatment conditions did not adversely affect the physicochemical quality of the oil, suggesting that controlled heating can be effectively employed to improve extraction efficiency without compromising oil integrity.

Overall, the study establishes that *Mormyrus rume* possesses considerable potential as an alternative local source of high-quality fish oil. Its exploitation could contribute to reducing dependence on imported marine fish oils, improving resource utilization of freshwater fish species, and supporting sustainable fish oil production for nutritional, pharmaceutical, and industrial purposes.

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