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Fatty Acid and Triacylglycerol Profiles of Seed Oil from *Pachira glabra* Collected in Foura, Republic of the Congo

Nguie Gueko Séraphin[1,2], Ossoko Jean Paul Latran[1,2], Okandza Yves[1], Miakayizila Blaise Divin Emmanuel[1,2*], Mvoula Tsieri Michel Didace[1,3]

[1]Food Control and Quality Laboratory, National Higher School of Agronomy and Forestry, Marien NGOUABI University, Brazzaville, Congo
[2]National Institute for Research in Engineering Sciences, Innovation and Technology, Brazzaville, Congo
[3]Denis SASSOU NGUESSO University, Brazzaville, Congo
Email: *Blaisemiakayizila@gmail.com, *Blaisemiak@gmail.com

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Abstract

Pachira glabra, locally known as "Nguba ya mputu" across the two banks of the Congo River, is an oleaginous plant highly appreciated for its edible seeds rich in nutrients, particularly lipids. In Congo-Brazzaville, this species remains insufficiently investigated regarding its fatty acid and triacylglycerol compositions despite its presence across several localities. The objective of this work was to determine the fatty acid and triacylglycerol profiles of oil extracted from *Pachira glabra* seeds collected in Foura, Boundji sub-prefecture, Republic of the Congo. Oil was extracted using a Soxhlet apparatus with n-hexane and transesterified with boron trifluoride (BF_3) for fatty acid analysis by gas chromatography. A probabilistic 1,2,3-random distribution approach was applied to predict triacylglycerol molecular species and compare them with the major experimental groups (C48, C50, C52). The results show an oil yield of 44.97% ± 0.01% with high saturated fatty acid content (62.43% ± 3.50%), dominated by palmitic acid (57.78% ± 3.50%), followed by oleic acid (8.8% ± 0.70%) and (**n-6**) cis-linoleic acid (5.67% ± 0.50%). The oil also revealed atypical cyclopropenic fatty acids (22.50% ± 1.80%), notably sterculic acid (20.08% ± 1.60%), dihydrosterculic acid (1.31% ± 0.50%), and malvalic acid (1.11% ± 0.50%). Triacylglycerol carbon number profiling was dominated by C50 (41.27% ± 3.30%), C52 (9.38% ± 0.75%), and C48 (3.72% ± 0.50%). The probabilistic model identified tripalmitin (PPP, 20.28%), oleyl-dipalmitoyl-glycerol (OPP, 9.26%), linoleyl-dipalmitoyl-glycerol (LPP, 5.97%), and dipalmitoyl-stearoyl-glycerol (PPS, 3.80%) as major species. Due to the massive presence of cyclopropenic fatty acids known as Δ^9-desaturase inhibitors and antinutritional factors, di-

rect edible consumption of this crude oil cannot be recommended. Valorization should primarily focus on non-food applications, such as oleochemistry, biolubricants, cosmetics, and topical pharmaceuticals.

Keywords

Pachira glabra, Lipids, Cyclopropenic Fatty Acids, Probabilistic Model, Congo

1. Introduction

In African countries in general, and in Congo-Brazzaville in particular, food security relies heavily on the valorization of local biodiversity. In the intertropical zone, this floristic potential includes a major source of plant species whose exploitation remains largely artisanal. Among these plants, oilseeds play an essential role in human nutrition, agro-industries, and various industrial applications. They represent an important source of lipid-rich seeds capable of being exploited for vegetable oil production required by food, cosmetic, and pharmaceutical industries [1]-[3]. However, global industrial vegetable oil production is overwhelmingly dominated by a limited number of species, such as oil palm, soybean, rapeseed, sunflower, peanut, coconut, cotton, sesame, and olive [4]-[6].

Nevertheless, numerous oil-bearing plant species yielding lipid-rich seeds remain underutilized and are drawing growing scientific interest, particularly in tropical regions endowed with high biodiversity [3]. Among these species is *Pachira glabra*, a tropical fruit tree with considerable agro-alimentary, health, and socio-economic potential. Its seeds could be processed but are unfortunately neglected and wasted from season to season. Studies conducted in Congo-Brazzaville indicate that these seeds are rich in lipids (39.35%) and contain bioactive molecules such as polyphenols, flavonoids, and tannins [7] [8].

Despite existing studies on this plant in Congo-Brazzaville, *P. glabra* from Foura in the Boundji district (Cuvette department) has never been subjected to detailed biochemical investigation. The present study aims to expand current knowledge on Congolese *Pachira glabra* by characterizing the fatty acid and triacylglycerol profiles of oil extracted from Foura seeds. This research provides evidence-based data for the prospective industrial and non-food valorization of these seeds.

2. Materials and Methods

2.1. Plant Material

Mature fruits of *Pachira glabra* were collected in Foura, Boundji district, Cuvette Department, Republic of the Congo. Fruits were transported to the laboratory, where hulls were removed. Extracted seeds were dried in an oven at 60˚C for 72 h until constant mass was achieved, then finely ground using an electric grinder (Cookwork). The resulting powder was used for oil extraction.

2.2. Oil Extraction

Fat content extraction was performed continuously using the Soxhlet method [9]. Powdered seed material (30 g) was placed into a cellulose thimble inserted into the extractor. A round-bottom flask containing 200 mL of n-hexane was heated at reflux for 3 h. Following extraction, the solvent was evaporated under reduced pressure. The residual golden-yellow oil was recovered, weighed, and stored in dark glass containers under refrigeration for subsequent analyses. The extracted oil was analyzed at the laboratory of the Technical Institute for Studies and Research on Fats (ITERG, France) in March 2026 to determine its fatty acid and triacylglycerol profiles.

2.3. Determination of Fatty Acid Profile

2.3.1. Preparation of Fatty Acid Methyl Esters (FAME)

Fatty acids were converted into fatty acid methyl esters (FAME) by transesterification using boron trifluoride (BF_3) according to international standard ISO 12966-2 [10]. Oil drops were dissolved in 1 mL of n-hexane, to which 0.4 mL of a methanolic sodium hydroxide solution was added. The mixture was refluxed at 60˚C for 10 min. Subsequently, 0.5 mL of BF_3 reagent and 1 mL of n-hexane were added, followed by heating for three minutes. After vigorous shaking, the mixture was allowed to settle into two phases. Upon cooling and decantation, the upper hexane phase containing FAME was collected.

2.3.2. Gas Chromatography (GC-FID) Separation and Quantification

FAME analysis was conducted using a Hewlett-Packard HP 5890 gas chromatograph equipped with a non-polar capillary column (HP-5MS, length 30 m, internal diameter 0.25 mm, film thickness 0.2 µm) and a Flame Ionization Detector (FID) in accordance with ISO 12966-4 [11]. Helium served as the carrier gas at a flow rate of 1 mL/min. The oven temperature was programmed from 50˚C to 280˚C at 5˚C/min. Injector and detector temperatures were set to 250˚C and 280˚C, respectively. An injection volume of 1 µL was used.

Fatty acids were identified by comparing retention times with those of authentic standard mixtures injected under identical conditions. The quantification of fatty acids was achieved by measuring peak areas. A standard of known concentration, heptadecanoic acid (C17:0), was used in this process. By adding a known amount of C17:0 to the studied fat, the fatty acids present in the sample could be accurately determined. The comparison of their peak areas was performed relative to that of C17:0 as follows:

$$\mathrm{FA}(\mathrm{mg}) = \mathrm{mass}(\mathrm{C17:0}) \times \left[\frac{\mathrm{Area}(\mathrm{FA})}{\mathrm{Area}(\mathrm{C17:0})} \right] \tag{1}$$

$$\%\mathrm{FA} = \frac{\mathrm{FA}(\mathrm{mg})}{\mathrm{Total\ FA}(\mathrm{mg})} \tag{2}$$

In compliance with COFRAC/ISO metrological standards, fatty acid concentrations are reported with their expanded measurement uncertainty *U(%)* at a

95% confidence level ($k = 2$).

2.4. Determination and Modeling of Triacylglycerols (TAGs)

2.4.1. Global Experimental Analysis

The global experimental analysis of intact triglycerides, separated by their total number of carbon atoms (e.g., C52, C54), was carried out using gas chromatography (GC). The analysis was performed by the laboratory of the Technical Institute for Studies and Research on Fats (ITERG, France) in strict compliance with the standardized methods IUPAC 2.323 [12] and NF EN ISO 17678 [13]. Following these normative protocols, the identification of triglyceride groups was performed by comparing their retention times with those of established reference standards, and relative quantification was achieved by determining the percentage of the respective chromatographic peak areas.

2.4.2. Probabilistic Distribution Approach

Standard chromatographic techniques (HPLC/GC) often struggle to resolve all positional isomers of complex triacylglycerols. To overcome this limitation and provide a representative structural map of species in Pachira glabra oil, the mathematical "genetic code" framework established by Ossoko and al 2017 [14] was applied based on 1,2,3-random statistical distribution theory.

This model posits that during seed biosynthesis, acyltransferase esterification across the three positions (sn-1, sn-2, sn-3) of glycerol occurs with a probability proportional to the molar fraction of each fatty acid in the pool. The probability $P(A, B, C)$ of forming a triacylglycerol composed of fatty acids A, B and C is defined by:

$$P(A,B,C) = \frac{3!}{n_A! \cdot n_B! \cdot n_C!} \times [A] \times [B] \times [C]$$

where:

$[A]$, $[B]$ and $[C]$ represent the normalized molar fractions of individual fatty acids, and n_i represents the frequency of recurrence of fatty acid within the triacylglycerol molecule.

Probabilities were calculated using the seven major fatty acids identified by GC-FID: palmitic (P), oleic (O), stearic (S), linoleic (L), sterculic (St), dihydrosterculic (D), and malvalic (M) acids. This model applies specifically to the characterized experimental fraction of the oil.

3. Results

3.1. Oil Content

Oil extraction was performed in six replicates to ensure reproducibility. The mean extraction yield was 44.97% ± 0.01%, confirming that *Pachira glabra* seeds represent a high-yielding oilseed resource.

3.2. Fatty Acid Composition

The fatty acid composition of *Pachira glabra* seed oil determined by GC-FID fol-

lowing transesterification is presented in Table 1. The total measured fatty acid content was 78.533g/100g of crude oil, representing the absolute fatty acid yield. The individual fatty acid group proportions detailed in Table 1 are expressed as relative percentages of the total quantified fatty acids (g/100g of total FAME).

Table 1. Fatty acid composition of *Pachira glabra* seed oil collected in Foura, Congo.

Fatty acid groups	Common name	Symbol	Content (% ± U)	Total groups (% ± U)
Saturated Fatty Acids (SFA)	Myristic acid	C14:0	0.31% ± 0.50%	62.43% ± 3.50%
	Palmitic acid	C16:0	57.78% ± 3.50%	
	Margaric acid	C17:0	0.15% ± 0.50%	
	Stearic acid	C18:0	3.61% ± 0.50%	
	Arachidic acid	C20:0	0.40% ± 0.50%	
	Behenic acid	C22:0	0.09% ± 0.50%	
	Lignoceric acid	C24:0	0.08% ± 0.50%	
Monounsaturated Fatty Acids (MUFA)	Myristoleic acid	C14:1	<0.05%	9.13% ± 0.75%
	Palmitoleic acid isomers	C16:1	0.28% ± 0.50%	
	Heptadecenoic acid	C17:1	<0.05%	
	Malvalic acid (trans)	C18:1 trans	0.07% ± 0.50%	
	Oleic acid	C18:1 n-9	8.04% ± 0.64%	
	Vaccenic acid	C18:1 n-7	0.76% ± 0.50%	
	Oleic acid and cis isomers	C18:1 cis	8.8% ± 0.50%	
	Erucic acid	C22:1	<0.05%	
	Nervonic acid	C24:1	<0.05%	
	8-Eicosenoic acid	C20:1 (n-12)	0.05%	
Polyunsaturated Fatty Acids (PUFA)	Linolenic acid (trans)	C18:2 trans	<0.05%	5.87% ± 0.50%
	Linoleic acid (cis)	C18:2 cis	5.67% ± 0.50%	
	Alpha-Linolenic acid	C18:3 (n-3) cis	<0.05%	
Cyclopropenic Fatty Acids (CPFA)	Sterculic acid	C19:1 cpe	20.08% ± 1.60%	22.50% ± 1.80%
	Dihydrosterculic acid	C19:0 cpa	1.31% ± 0.50%	
	Malvalic acid	C18:1 cpe	1.11% ± 0.50%	
Total Trans Fatty Acids	Unidentified trans		0.07% ± 0.50%	0.07% ± 0.50%

Saturated fatty acids overwhelmingly dominate the profile (62.43% ± 3.50%), with palmitic acid being the main constituent (57.78% ± 3.50%), followed by stearic acid (3.61% ± 0.50%). Monounsaturated fatty acids represent 9.13% ± 0.75%,

dominated by oleic acid isomers (8.8% ± 0.50%). Polyunsaturated fatty acids total 5.87% ± 0.50%, composed primarily of cis-linoleic acid (5.67% ± 0.50%). The unsaturated-to-saturated ratio (U/S) is 0.24, and the MUFA/PUFA ratio is 1.5.

A key biochemical feature is the notable concentration of cyclopropenic fatty acids (22.50% ± 1.80%), comprising sterculic acid (20.08% ± 1.60%), dihydrosterculic acid (1.31% ± 0.50%), and malvalic acid (1.11% ± 0.50%).

3.3. Experimental Triacylglycerol Analysis

Gas chromatographic grouping of intact triacylglycerols by total carbon number is detailed in Table 2.

Table 2. Experimental triacylglycerol distribution of *Pachira glabra* seed oil by carbon number.

Triacylglycerol Group (Carbon Number)	Result (%)
C48	3.72% ± 0.50%
C50	41.27% ± 3.30%
C52	9.38% ± 0.75%
Unidentified	45.63% ± 3.60%

Experimental determination revealed a profile dominated by C50 (41.27%), followed by C52 (9.38%) and C48 (3.72%), alongside a large unidentified fraction (45.63%).

3.4. Triacylglycerol Profiling by Probabilistic Approach

To model the triacylglycerol architecture across groups C48 to C52, the stochastic model proposed by Ossoko *et al.* 2017 [14] was executed. The molar fractions of the seven main fatty acids were normalized to 1.000 (dividing by their cumulative sum of 0.9835), as listed in Table 3.

Table 3. Main identified fatty acids and normalized molar fractions.

Fatty Acid	Code	Mass content (%)	Molar fraction	Normalized fraction
Palmitic acid (*P*)	C16:0	57.78	0.5778	0.5875
Sterculic acid (*St*)	C19	20.08	0.2008	0.2042
Oleic acid (*O*)	C18:1 cis	8.8	0.088	0.0895
Linoleic acid (*L*)	C18:2 cis	5.67	0.0567	0.0577
Stearic acid (*S*)	C18:0	3.61	0.0361	0.0367
Dihydrosterculic acid (*D*)	C19	1.31	0.0131	0.0133
Malvalic acid (*M*)	C18	1.1	0.011	0.0112

(Legend: *P* = Palmitic acid, *St* = Sterculic acid, *O* = Oleic acid, *L* = Linoleic acid, *S* = Stearic acid, *D* = Dihydrosterculic acid, *M* = Malvalic acid).

Structural constraints dictate that C48 species arise exclusively from three C16 acyl chains (C16 + C16 + C16). C50 species require two C16 chains and one C18 chain (2 × C16 + C18), while C52 species require one C16 chain and two C18 chains (1 × C16 + 2 × C18).

Summed molar fractions for carbon classes were established as: C16 = 0.5875; C18 = 0.1951 (sum of *O*, *L*, *S*, *M*); and C19 = 0.2175 (sum of *St*, *D*).

Applying theoretical cumulative probability equations and propagating analytical uncertainties via $U_P = P \times \sqrt{\sum \left(C_i \times \frac{U_i}{x_i} \right)^2}$, yields:

- $P(48) = (0.5875)^3 \times 100 = 20.28 \pm 2.13\%$.
- $P(50) = 3 \times (0.5875)^2 \times (0.1951) \times 100 = 20.19 \pm 1.65\%$.
- $P(52) = 3 \times (0.1951)^2 \times (0.5875) \times 100 = 6.71 \pm 0.85\%$.

The theoretical cumulative probability of TAG species containing at least one cyclopropenic fatty acid (C19), such as group C51 (2C16 + 1 × C19), was calculated using the complementary probability:

$$P_{CPFA} = \left[1 - (1 - C_{19})^3 \right] \times 100 = \left[1 - (1 - 0.2175)^3 \right] \times 100 = 52.10 \pm 3.19\%$$

This predicted value (52.10% ± 3.19%) aligns with the experimental unidentified chromatographic fraction (45.63% ± 3.60%), as cyclopropenic rings are thermolabile and undergo thermal degradation during high-temperature GC analysis.

The predicted individual molecular species of triacylglycerols are detailed in Table 4.

Table 4. Probabilistic modeling of major and minor triacylglycerol species of *Pachira glabra* oil.

Total Carbon Group	Triacylglycerol Species	Acyl Combination	Estimated Probability (%)
C48	*PPP*	Tripalmitin	20.28% ± 1.62%
C50	*OPP*	Oleyl-dipalmitoyl-glycerol	9.26% ± 0.74%
	LPP	Linoleyl-dipalmitoyl-glycerol	5.97% ± 0.50%
	PPS	Dipalmitoyl-stearoyl-glycerol	3.80% ± 0.50%
	PPM	Malvalyl-dipalmitoyl-glycerol	1.16% ± 0.50%
C52	*LOP*	Linoleyl-oleyl-palmitoyl-glycerol	1.82% ± 0.50%
	OOP	Dioleyl-palmitoyl-glycerol	1.41% ± 0.50%
	OPS	Oleyl-palmitoyl-stearoyl-glycerol	1.16% ± 0.50%
	LPS	Linoleyl-palmitoyl-stearoyl-glycerol	0.75% ± 0.50%
	LLP	Dilinoleyl-palmitoyl-glycerol	0.59% ± 0.50%
	MOP	Malvalyl-oleyl-palmitoyl-glycerol	0.35% ± 0.50%
	PSS	Palmitoyl-distearoyl-glycerol	0.24% ± 0.50%

Continued

LMP	Linoleyl-malvalyl-palmitoyl-glycerol	0.23% ± 0.50%
MPS	Malvalyl-palmitoyl-stearoyl-glycerol	0.14% ± 0.50%
MMP	Dimalvalyl-palmitoyl-glycerol	0.02% ± 0.50%

(Legend: *P* = Palmitic acid, *St* = Sterculic acid, *O* = Oleic acid, *L* = Linoleic acid, *S* = Stearic acid, *D* = Dihydrosterculic acid, *M* = Malvalic acid).

Tripalmitin (*PPP*, 20.28% ± 1.62%) forms the sole species of the C48 group. The C50 group is dominated by *OPP* (9.26% ± 0.74%), *LPP* (5.97% ± 0.50%), and *PPS* (3.8% ± 0.50%). Minor species in group C52 (6.7% ± 0.50%) include *LOP* (1.82% ± 0.50%), *OOP* (1.41% ± 0.50%), and *OPS* (1.16% ± 0.50%).

4. Discussion

4.1. Oil Extraction Yield

The high oil yield obtained (44.97% ± 0.01%) confirms *Pachira glabra* as a notable non-conventional oilseed resource in the Congo Basin [3]. This value (44.97%) is consistent with values reported for *Pachira glabra* and *Pachira macrocarpa* by Akinyede & Ajewole (43.33%) [15] and Zhang *et al.* (43.34%) [16]. It exceeds values reported by Yoca *et al.* (39.38%) [7] in Congo and Ayodele & Badejo (37.02%) [17] in Nigeria for *P. glabra.* These differences may stem from soil composition, seed maturity at harvest, extraction conditions, and post-harvest storage.

Comparatively, this lipid content is higher than that of hemp seed oil (30.2%) [18] and olive oil (21%) [19], but lower than sesame oil (49.1%) [20] and argan kernel oil (66.52%) [21].

4.2. Fatty Acid Profile

Pachira glabra seed oil from Foura is characterized by a high saturated fatty acid content (62.43% ± 3.50%), dominated by palmitic acid (57.78% ± 3.50%). This palmitic acid concentration exceeds that of conventional tropical fats such as palm oil (44% - 48%) and cocoa butter (25% - 30%). Classical unsaturations remain modest, with oleic acid at 8,04% and linoleic acid at 5.67%. The linoleic acid content (5.67%) is close to values reported for *Vitellaria paradoxa* seed fat (5.86%) in Congo [22] and shea butter (3% - 9%) [5].

The low unsaturated-to-saturated ratio (U/S = 0.24) explains why *Pachira glabra* oil remains solid or semi-solid at tropical ambient temperatures, similar to palm oil or shea butter [23]. Furthermore, the MUFA/PUFA ratio of 1.50 indicates enhanced intrinsic stability against autoxidation and thermal rancidity compared to polyunsaturated fluid oils like soybean or sunflower oils.

These results mirror historical literature on *Pachira glabra* (syn. *Bombacopsis glabra*). Cornelius *et al.* 1965 [24] and Chaves *et al.* 2012 [25] reported 43.0% and 53.06% palmitic acid, 12.0% and 7.42% oleic acid, 7.80% and 4.73% and linoleic acid, respectively. Breyne [26] also documented palmitic acid levels exceeding

50%.

The signature feature of *P. glabra* oil is the presence of cyclopropenic fatty acids (22.50% ± 1.80%), mainly sterculic acid (20.08%), dihydrosterculic acid (1.31%), and malvalic acid (1.11%). These cyclic fatty acids are characteristic of the *Malvaceae* family (including former *Bombacaceae* and *Sterculiaceae*). Similar values were reported by Cornelius *et al.* 1965 (34.50%, sterculic acid) [24], Chaves *et al.* 2012 (26.5% total CPFA by GC-FID, 26.2% - 30.9% by NMR) [25], and Breyne 1993 (24.5% - 34.0%) [26].

Nutritively and toxicologically, cyclopropenic fatty acids act as potent antinutritional factors [27]. The strained cyclopropene ring irreversibly binds to sulfhydryl groups of the enzyme Δ^9-desaturase (stearoyl-CoA desaturase), inhibiting the metabolic conversion of stearic acid (C18:0) to oleic acid (C18:1). In mammals, CPFA ingestion causes hepatic steatosis, membrane permeability alterations, growth retardation, reduced fertility, and co-carcinogenic activity [25] [27]. Furthermore, the chemical instability of the cyclopropene ring promotes rapid oxidative degradation (Rancimat induction time of only 4.18 h) [25]. Consequently, direct human consumption of crude *Pachira glabra* oil or unrefined seeds must be avoided.

However, this unique structure offers prospective non-food applications. The high palmitic acid content (57.78%) provides a high saponification value (178 - 188 mg KOH/g) suitable for soap production [28]. Bello & Oladepo [28] demonstrated the formulation of an antifungal ketoconazole soap using *P. glabra* oil, exhibiting strong foam stability (133 min) and intrinsic antimicrobial activity against *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans*, and *Trichophyton rubrum*. Additionally, thermogravimetric analysis (TG/DTG) shows high thermal stability (Tonset = 381.83˚C) [25]. Combined with the reactivity of the cyclopropene ring, this enables chemical modifications (epoxidation, polymerization) for bio-based lubricants, industrial resins, and topical pharmaceuticals.

4.3. Architecture of Triacylglycerols: Insights from the Probabilistic Model and Impact of Cyclopropenic Acids

Gas chromatographic analysis of intact triacylglycerols revealed a substantial unidentified fraction (45.63% ± 3.60%). This limitation is attributed to the presence of cyclopropenic fatty acids (22.50% ± 1.80%), whose thermal instability causes degradation inside high-temperature GC columns [24] [25].

Applying the 1,2,3-random stochastic model [14] across the total lipid pool resolved this analytical limitation. Dominance of class C50 (41.27%) and class C48 (3.72%) stems from the overall abundance of palmitic acid (57.78%). However, a significant discrepancy exists between the theoretically modeled *PPP* (20.28%) and the experimentally observed C48 fraction (3.72%). This overestimation occurs because the purely mathematical 1,2,3-random distribution does not account for the strict regiospecificity of biological plant lipid biosynthesis, wherein saturated fatty acids like palmitic acid are largely excluded from the sn-2 position,

thereby strictly limiting the actual formation of tripalmitin in vivo. The model predicts 20.28% tripalmitin (*PPP*) in group C48; 20.20% for non-CPFA species in group C50 (*OPP* 9.26%, *LPP* 5.97%, *PPS* 3.80%, *OOP* 1.41%, *PPM* 1.16%); and critically predicts that 52.10% ± 1.80% of synthesized triacylglycerols contain at least one cyclopropenic chain (C19). This theoretical value matches the unassigned experimental fraction (45.63% ± 3.60%).

Following the classification framework of Silou [3], *Pachira glabra* oil exhibits a $\%P > \%O > \%L > \%S$ profile, structurally relating it to palmitic fractions of palm oil (*Elaeis guineensis*). Highly saturated TAGs such as *PPP* and *OPP* provide hardness, foam stability, and oxidation resistance in cosmetic and soap formulations [28]. Further investigations utilizing liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS) will be beneficial to directly confirm the individual CPFA-containing molecular species.

5. Conclusion

This study characterized the yield, fatty acid profile, and triacylglycerol architecture of *Pachira glabra* seed oil from Foura, Republic of the Congo. The oil is rich in saturated fatty acids (62.43%), dominated by palmitic acid (57.78%). Application of a 1,2,3-random probabilistic distribution model elucidated the triacylglycerol structure, highlighting tripalmitin (*PPP*, 20.28%) as the primary C48 species, alongside major C50 species (*OPP, LPP, PPS*). The study confirmed the presence of cyclopropenic fatty acids (22.50%), primarily sterculic acid (20.08%). Due to the antinutritional and metabolic toxicity of CPFA rings (desaturase inhibition), crude *Pachira glabra* oil cannot be recommended for edible purposes. Industrial valorization should focus on non-food applications including oleochemistry, biolubricants, soap manufacturing, cosmetics, and topical pharmaceutical formulations.

Author Contributions

- **Original Draft Preparation:** NGUIE GUEKO Séraphin.
- **Conceptualization and Methodology:** OSSOKO Jean Paul Latran, OKANDZA Yves, MIAKAYIZILA Blaise Divin Emmanuel.
- **Formal Analysis:** OKANDZA Yves, NGUIE GUEKO Séraphin.
- **Writing—Review & Editing:** MIAKAYIZILA Blaise Divin Emmanuel, OSSOKO Jean Paul Latran, NGUIE GUEKO Séraphin.
- **Validation:** OSSOKO Jean Paul Latran, MIAKAYIZILA Blaise Divin Emmanuel.
- **Supervision:** OSSOKO Jean Paul Latran.
- **Project Administration:** MVOULA TSIERI Michel Didace.

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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