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Original Article

Lipidic composition and thermal stability of oils from *Dipteryx alata, Acrocomia totai, Mauritia flexuosa* and *Caryocar brasiliense*

Composição lipídica e estabilidade térmica dos óleos de *Dipteryx alata*, *Acrocomia totai*, *Mauritia flexuosa* e *Caryocar brasiliense*

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Abstract

Vegetable oils have various types of applications, one of which is food. *Dipteryx alata* (“baru” or tonka bean) and *Acrocomia totai* (“bocaiuva”, or macaw palm) nuts, *Mauritia flexuosa* (“buriti”, or buriti palm), and *Caryocar brasiliense* (“pequi”, or pequi fruit) pulps are sources of unsaturated lipids. By performing quality, identity, and stability analyses, it is possible to check whether these oils are proper for human nutrition. Oils of tonka bean and pequi fruit had acceptable acidity values, while macaw palm oils had values above those allowed by the *Codex Alimentarius*. The peroxide index was within the recommended value in all samples. In addition, the refractive index and relative density were similar for all oils. The coloring indicated the possible presence of chlorophyll in tonka bean and macaw palm oils, and carotenoids in buriti palm and pequi fruit oils. The fatty acid profile revealed that macaw palm, buriti palm, and pequi fruit oils are mostly monounsaturated, while *A. totai* oil exhibited a predominantly saturated profile. The nutritional quality indices demonstrated that the oil with the most similar quality to olive oil was that of buriti palm. UV-vis and fluorescence analysis indicated that pequi fruit and buriti palm oils contain beta-carotene, while tonka bean and macaw palm oils have alpha-tocopherol. Finally, thermal analyses showed that tonka bean and buriti palm oils have the highest stability at high temperatures, indicating the best potential for culinary use.

Keywords: Brazilian Cerrado, crude vegetable oil, fatty acid profile, oxidative stability, thermal analysis.

Resumo

Os óleos vegetais possuem diversos tipos de aplicações, sendo a alimentação uma delas. As castanhas do baru e da bocaiuva e as polpas do buriti e do pequi, são fonte de lipídios insaturados. Realizando análises de qualidade, identidade e estabilidade, é possível verificar se existe a possibilidade desses óleos integrarem a alimentação humana. O presente estudo demonstrou que os óleos de baru e pequi tiveram valores aceitáveis de acidez, enquanto os óleos de bocaiuva e buriti obtiveram valores acima do permitido pelo *Codex Alimentarius*. O índice de peróxido ficou dentro do valor preconizado em todas as amostras, ademais, o índice de refração e a densidade relativa foi similar para todos os óleos. A coloração indicou que pode existir a presença de clorofila no óleo de baru e óleo de bocaiuva e carotenoides no óleo de buriti e óleo de pequi. O perfil de ácidos graxos revelou que o óleo de baru, óleo de buriti e óleo de pequi são majoritariamente monoinsaturados, enquanto o óleo de bocaiuva tem um perfil predominantemente saturado. Os índices de qualidade nutricional demonstraram que o óleo com qualidade mais parecida com o azeite de oliva foi o óleo de buriti. As análises de UV-vis e fluorescência indicaram que o óleo de pequi e óleo de buriti possuem beta-caroteno, enquanto o óleo de baru e o óleo de bocaiuva possuem alfa-tocoferol. Por fim, as análises térmicas mostram que o óleo de baru e o óleo de buriti possuem maior estabilidade em altas temperaturas, indicando um potencial uso culinário.

Palavras-chave: Cerrado brasileiro, óleo vegetal bruto, perfil de ácidos graxos, estabilidade oxidativa, análise térmica.

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1. Introduction

Brazil leads the global oilseed production, with over 158 million metric tons in 2023 and 2024, followed by the U.S.A. and China, with approximately 122 and 69 million metric tons, respectively (USDA, 2025).

In the Cerrado and Pantanal biomes, there are various nut-bearing trees with lipid potential, such as *Dipteryx alata* Vogel (tonka bean or "baru"), *Acrocomia totai* (macaw palm, "bocaiuva" or "macaúba"), *Mauritia flexuosa* L.f. (buriti palm or "buriti"), and *Caryocar brasiliense* Cambess. (pequi fruit or "pequi"). Pressed, they can provide crude vegetable oils with a high nutritional value, since these fruits are rich in unsaturated fatty acids (Vale et al., 2019; Queiroz et al., 2025; Silva et al., 2025; Sobral et al., 2025; Sorita et al., 2025).

The indices of identity and quality, such as acidity, peroxide value, and refraction, are tools that help identify if an oil has undergone alteration, such as oxidation and deterioration. The profile of fatty acids indicates whether it is interesting from the nutritional viewpoint for the human diet. The analysis of thermal stability indicates the safe maximum temperature at which an oil can be heated without any alteration. The oxidative stability verifies the resistance of an oil to oxidation when exposed to a sudden increase in temperature (Khoddami et al., 2014; Santos et al., 2016; Aremu et al., 2017; Lužaić et al., 2022). Thus, our research had the objective to characterize the physical-chemical features of the crude oils from native Cerrado fruits, analyze their fatty acid profile, and to verify their optical and thermal analyses, aiming at their potential as edible oils.

2. Material and Methods

2.1. Raw matter

The nuts of macaw palm and tonka bean were acquired at the Centro de Produção Pesquisa e Capacitação do Cerrado (CEPPEC) (Nioaque-MS), and the oils were extracted in a domestic hydraulic press (Yoda Nut & Seed Cold Press Oil, Extractor-Gourmet Extractor, Homeup, Yoda Europe, Cluj-Napoca, Romania), with a mean yield of 15%.

2.2. Quality and identity indices of crude oils

2.2.1. Acidity index

The oil acidity index was determined by adding a neutralized ether–alcohol (1:1) solution and phenolphthalein to indicate color change. We utilized potassium hydroxide (KOH) 0.1 M as a titrant until the color changed to pink. The results are expressed as mgKOH/g and g of oleic acid/100 g oil (IAL, 2008).

2.2.2. Peroxide index

To verify the peroxide index, we added c. 1.0 g to each oil sample. Then, we added a solution of glacial acetic acid and chloroform (3:2) and, next, 0.1 mL of a saturated solution of potassium iodine. Later, we added distilled water and soluble starch at 1% as an indicator. After, it was titrated with sodium thiosulfate at 0.01M until the mixture became translucent (IAL, 2008).

2.2.3. Refraction index

The refraction index of the oils was obtained with an Abbé refractometer (RL3, Tecnal, Brazil) calibrated with distilled water, with a refraction index of 13.330, at 27 °C, temperature-corrected to 40 °C (IAL, 2008).

2.2.4. Saponification index

We determined the saponification index by adding a solution of alcohol and potassium hydroxide (KOH) at 4% (m/v) to the samples and refluxing for 1 h. Next, we used phenolphthalein to indicate color change and titration with chloric acid (HCl) 0.5 M. The results were expressed as mgKOH/g (IAL, 2008).

2.2.5. Iodine index

The iodine index was obtained by adding carbon tetrachloride and Wijs solution to the oils, and standard sodium thiosulfate was used as a titrant until the color changed from black to pink. The results were expressed as g I_2/100 g (IAL, 2008).

2.2.6. Relative density

We determined the relative density by using the pycnometer method, with prior taring in an oven at 105 °C. Then, we added a mixture of alcohol and water at 20–23 °C and placed it in a bath at a constant temperature (25 ± 0.1 °C). We repeated the same procedures with the oils. The results were expressed as mg/mL (IAL, 2008).

2.3. Coloration

For the analysis, a colorimeter (CM-2300d, Konica Minolta®, USA) was used, expressing the results in the scale CIE L*a*b* (Konica Minolta, 2025).

2.4. Fatty acid profile

We the fatty acids according to a method adapted from Hartman and Lago (1973). The methyl esters were analyzed by gas chromatography (GC 2010, Shimadzu®, Japan), and their individual peaks of FAMEs were identified by comparing their relative retention times with the standard of 37 FAMEs (Supelco® C22, 99% pure).

2.5. Nutritional quality index

The oil nutritional quality was determined according to the atherogenicity index (IA), thrombogenicity index (IT), and hypercholesterolemic/hypocholesterolemic relation (HH) (Ulbricht and Southgate, 1991).

2.6. Optic analyses: UV-vis and fluorescence

Oil samples were diluted in Hexane Sigma-Aldrich® grade HPLC 99.9% in two concentrations, 0.5 and 16.6% (v/v), to perform optical measures. A spectrophotometer of band Lambda 265 UV/Vis, Perkin Elmer®, Waltham, MA, USA was used for measurements of UV-Vis absorption.

2.7. Thermal analysis: TG/DTG and DSC

The TG/DTG curves of oils were obtained using a thermal analysis system (TGA Q50 of TA Instruments®), and platinum crucibles for samples. The DSC curves were obtained by DSC Q20 of TA Instruments® coupled to a RCS 90 refrigeration system (Refrigerated Cooling System).

2.8. Statistical analyses

The results were expressed as mean ± standard deviation of the mean. The one-way analysis of variance (one-way ANOVA) was used for multiple comparisons, followed by the Tukey post-test or Dunn post-test. The significance level adopted was $p<0.05$. For statistical analyses, the software Jandel SigmaStat, version 3.5 for Windows (Systat software®, Inc., USA) was used. The statistical analyses were performed on acidity, peroxide, refraction, saponification, relative density, and fatty acid profile.

3. Results and Discussion

3.1. Quality and identity indices of Cerrado oils

In Table 1, we show the values obtained for oils of tonka bean, macaw palm, buriti palm, and pequi fruit. The quality and identity indices applied to oils are used to evaluate whether a food is appropriate for consumption, fitting the parameters according to the legislation and without signs of deterioration (Meireles et al., 2022; Dudi et al., 2021).

The comparison of acidity index values in crude oils of tonka bean and macaw palm revealed a significant difference, and only the oils of buriti palm and pequi fruit did not differ. The peroxide index showed a significant difference among oils of buriti palm and pequi fruit, whereas the oils of tonka bean and macaw palm did not form peroxides. Regarding the refraction index, we did not find significant differences among any oils, nor in density. However, in the saponification index, we detected differences between the oils of tonka bean and pequi fruit, macaw palm and pequi fruit, and buriti palm and tonka bean.

The acidity indices of tonka bean and pequi fruit oils are within the values advised by the *Codex Alimentarius*, up to 4.0 mg KOH/g for crude oils. The buriti palm oil exhibited the highest acidity index among oils; therefore, it is considered non-edible without refining, but it can be used in its crude form in non-food products, such as cosmetics (Silva et al., 2024; FAO, 2024). The peroxide index stayed within the range of recommended values for crude oils (up to 15 mEq O_2/kg) in all oils. The refraction index was very similar for all oils. The oils we analysed do not have established parameters, but it is possible to compare them to extra-virgin olive oil, whose refraction index is 1.4677-1.4705, and to palm oil, with an index of 1.454-1.456 at 50 °C.

The tonka bean oil had the lowest saponification index, in contrast with the highest value of pequi fruit oil. Since the saponification index is inversely proportional to the molecular weight of the fatty acids present in oils, we can conclude that those with high saponification values are composed mainly of short and medium-chain fatty acids.

The results of the iodine index in oils of tonka bean and buriti palm indicate that they possess a high number of double bonds; thus, they are unsaturated oils. The pequi fruit oil obtained an intermediate value, demonstrating that it contains more saturated fatty acids than the first two. Furthermore, macaw palm oil presented the lowest iodine index, which indicates a high content of saturated fatty acids (FAO, 2024; Silva et al., 2025).

The relative density of all sampled oils was similar. They comply with crude oil standards, compared to olive oil (0.910-0.916) and palm oil (0.891-0.899). This parameter is associated with the composition of fatty acids of oils and can alter depending on temperature or lipid oxidation (Prates-Valério et al., 2019).

The analysis of color using the method CIE L*a*b* demonstrated that the tonka bean and macaw palm oils showed a clearer coloration, since they presented a higher L* value. Besides, for a negative value of a*, parameter that indicates a spectrum of red (+a*) to green (-a*), we can infer that they have a more greenish coloration, which can indicate the presence of chlorophyll. The buriti palm and pequi fruit oils exhibited a darker coloration, with lower values of L* (Pérez-Galvéz et al., 2020; Srivastava, 2021; Konica Minolta, 2025).

3.2. Profile of fatty acids and indices of nutritional quality of oils from the Cerrado

The oils of tonka bean, macaw palm, buriti palm, and pequi fruit had distinct compositions of fatty acids (Table 2). The

Table 1. Quality and identity indices of oils of tonka bean, macaw palm nut, buriti palm, and pequi fruit.

Indices	Tonka bean oil	Macaw palm nut oil	Buriti palm oil	Pequi fruit oil	p value
Acidity** (mg KOH/g)	0.64 ± 0.08^{d}	4.46 ± 0.18^{b}	12.45 ± 0.08^{a}	2.77 ± 0.05^{c}	<0.001*
Peroxide (mEq O_2/kg)	0.00 ± 0.00^{b}	0.00 ± 0.00^{b}	8.14 ± 0.91^{a}	7.89 ± 0.82^{a}	<0.001**
Refraction at 40 °C	1.468 ± 0,00	1.458 ± 0.00	1.466 ± 0.00	1.463 ± 0.00	
Saponification (mg KOH/g)	49.82 ± 21.91^{c}	79.41± 13.57^{bc}	107.95±13.84^{ab}	117.93 ± 2.06^{a}	0.002*
Iodine (g I_2/100 g)	93.04±0.97^{a}	52.10±3.39^{c}	91.69±8.00^{a}	78.78±3.25^{b}	<0.001*
Relative density (mg/mL)	0.8987 ± 0.00	0.8965 ± 0.00	0.8932 ± 0.00	0.9093 ± 0.00	
Coloration:					
L*	49.95	51.62	31.67	32.16	
a*	-3.86	-1.29	23.18	20.54	
b*	37.05	4.42	13.98	15.62	

The values were expressed as mean ± standard deviation.
*One-way ANOVA test. Means followed by different letters in the same line indicate significant difference between groups by the Tukey post-test at 5% probability. **Kruskal-Wallis test. Means followed by different letters in the same line indicate significant difference between groups by the Dunn post-test at 5% probability.

Table 2. Fatty acids profile of baru, bocaiuva, buriti and pequi oils (%).

Fatty acids	Tonka bean oil	Macaw palm oil	Buriti palm oil	Pequi fruit oil	p value
Saturated					
Lauric, C12:0	0.00 ± 0.00	26.07 ± 4.76	0.00 ± 0.00	0.00 ± 0.00	
Myristic, C14:0	0.00 ± 0.00	6.67 ± 1.20	0.00 ± 0.00	0.00 ± 0.00	
Palmitic, C16:0	5.26 ± 0.01b	6.29 ± 1.10ab	16.41 ± 0.11ab	40.33 ± 0.35a	0.024**
Estearic, C18:0	4.39 ± 0.01a	2.74 ± 0.47ab	1.65 ± 0.03b	1.86 ± 0.01ab	0.016**
Araquidic, C20:0	1.10 ± 0.00	0.16 ± 0.03	0.00 ± 0.00	0.00 ± 0.00	
Behenic, C22:0	2.96 ± 0.01	0.02 ± 0.02	0.00 ± 0.00	0.00 ± 0.00	
Lignoceric, C24:0	3.97 ± 0.01	0.06 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	
∑ TOTAL	**17.68**	**42.01**	**18.06**	**42.19**	
Monounsaturated					
Palmitoleic, C16:1					
Oleic, C18:1n9c	0.01 ± 0.01	0.01 ± 0.01	0.23 ± 0.00	0.75 ± 0.00	
Gadoleic, C20:1	54.33±0.04ab	27.38 ± 4.81b	77.48 ± 0.52a	53.38 ± 0.06ab	0.016**
Erucic, C22:1n9	0.00 ± 0.00b	0.12 ± 0.02ab	0.30 ± 0.01ab	0.07 ± 0.10a	0.023**
∑ TOTAL	0.28 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
Polyunsaturated	**54.61**	**27.51**	**78.01**	**54.2**	
Linoleic, C18:2n6c					
α-Linolenic, C18:3n3					
∑ TOTAL	24.46 ± 0.00a	2.43 ± 0.43ab	1.32 ± 0.04b	1.39 ± 0.03ab	0.016**
CNI*	0.10 ± 0.00ab	0.00 ± 0.00b	0.58 ± 0.0a	0.17 ± 0.12ab	0.033**
∑ TOTAL	**24.56**	**2.43**	**1.9**	**1.56**	
CNI*	**0.18**	**1.13**	**1.19**	**01.02**	

The values were expressed as mean ± standard deviation.
**Kruskal-Wallis test; *Means followed by different letters in the same line indicate significant difference between groups by the Dunn post-test at 5% probability.

tonka bean oil was composed of 17.80% saturated fatty acids, the principal being palmitic acid, 54.70% monounsaturated, its highest fraction, with prominence for the oleic acid and 24.56% polyunsaturated, 24.46% being linoleic acid. Santos et al. (2024) report in their review the average values of 50% monounsaturated, 30% polyunsaturated, and 20% saturated. Mendonça et al. (2024) found similar values in tonka bean oil with *c.* 53% of monounsaturated, 30% of polyunsaturated, and 15% of saturated.

The macaw palm nut oil contained the highest quantity of saturated lipids of all samples, nearly half its composition. Next, appear the monounsaturated fatty acids, mainly oleic, with more than 27%, and in lower proportion, the polyunsaturated fatty acids, with 2.43%. Silva et al. (2023) found slightly distinct values for macaw palm oil, with approximately 72% of saturated, 24% of monounsaturated, and 2% of polyunsaturated fatty acids. The predominantly saturated profile of macaw nut oil makes it suitable for use in biodiesel production, since higher levels of saturated fatty acids are associated with increased oxidative stability and higher cetane numbers (Duque et al., 2025; Pradana et al., 2024).

The buriti palm oil presented 18.06% de saturated fatty acids, with the palmitic standing out. The buriti palm oil had the highest monounsaturated fatty acid content among the four studied oils, with a total of 78.01%, being 77.48% oleic acid. The summation of total polyunsaturated fatty acids is only 1.95%. Besides, similar to our results, another study reported a composition of crude oil of buriti palm very close to ours, with 76.69% monounsaturated, 19.34% saturated, and 1.35% polyunsaturated fatty acids (Marcelino et al., 2022).

The pequi fruit oil had a similar quantity of saturated and monounsaturated fatty acids, of 42.19% and 54.20%, respectively. The fatty acid with the highest content was oleic, followed by palmitic. Carneiro et al. (2023) analysed the oil of pequi fruit cultivated in the state of Mato Grosso, and the profile of obtained fatty acids was approximately 43% saturated, 52% monounsaturated, and 1% polyunsaturated.

The AI indicates fatty acids with the potential to induce atherosclerosis, whereas TI indicates fatty acids that tend to form plaques in blood vessels, which increase the risk of cardiovascular diseases. The lower these indices, the better the oil composition and the lower the inflammatory potential (Ulbricht and Southgate, 1991; Menotti et al., 2024).

The HH is the relation between hypocholesterolemic and hypercholesterolemic fatty acids, and, like other indices, the lower, the better the oil lipidic composition

(Kmiecik et al., 2023; Tilami and Kouřimská, 2022). The oil with the highest AI was the macaw palm, in contrast with the lowest, which was the tonka bean (Table 3).

3.3. Optical analyses: UV-vis and fluorescence

Pequi fruit and buriti palm oils presented UV-Vis between 400 and 500 nm, characteristic of antioxidant substances of the carotenoid group (Figure 1), which can be attributed to the presence of beta-carotene due to the band shape, with the highest intensity of the central peak at approximately 450 nm (Silva et al., 2015; Faidi et al., 2016; Oliveira et al., 2017). The tonka bean oil presented an absorption band centered at 270 nm, with a region and characteristic shape of the natural alpha-tocopherol antioxidant (Silva et al., 2015; Oliveira et al., 2017).

Aligned with results of absorption, the pequi fruit and buriti palm oils presented emission bands characteristics of betacarotene, with higher emission intensity between 500 and 550 nm (Figure 2), indicating its presence in these vegetable oils, confirming the result seen before in the coloration analysis (Oliveira et al., 2017; Magalhães et al., 2014; Figueiredo et al., 2022). The carotenoids present in the crude oil of buriti palm can justify their use in dermocosmetics, since they offer photoprotection (Flieger et al., 2024). Similarly, pequi oil, characterized by a predominantly monounsaturated profile and high carotenoid content, has significant antioxidant and photoprotective potential, making it a promising alternative for the pharmaceutical and cosmetic industries, and can even be used in its raw form (Flieger et al., 2024). The crude oils of macaw palm nuts and tonka bean presented emissions in the region between 300 and 350 nm. These references attribute the emission to the tocopherol family of antioxidants, a known content of these vegetable oils (Oliveira et al., 2017; Figueiredo et al., 2022).

3.4. Thermal analysis: TG and DSC

The curves of thermogravimetry and derived thermogravimetry (TG/DTG) show the thermal stability and thermodecomposition behavior of the oils, related to the mass losses that occur as a function of controlled temperature variation (Santos et al., 2016; Carvalho et al., 2020). The thermal decomposition events of tonka bean, macaw palm, buriti palm, and pequi fruit oils are shown in Figure 3 and Table 4.

All oils, except tonka bean oil, had two steps of thermodecomposition. The first event of mass loss is attributed to the loss of water and minor mass volatile components. The second event, with a higher mass loss, shows degradation of the oil itself by decomposition of its fatty acids (Meireles et al., 2022; Marcelino et al., 2022).

Analysing Figure 3 and Table 4, the tonka bean oil had a single loss, that can be justified by the absence of short-chain fatty acids, such as acetic, propionic, buthyric and valeric acids, C2:0, C3:0, C4:0, and C5:0, respectively, with begin at 322 °C and end at 480 °C, without any residue, having the highest thermal stability. The macaw palm nut crude oil began its degradation at 105 °C, with a small mass loss, a higher decomposition at 262 °C, and ash residue of 2.35%; thus, it is the least stable under high temperatures. The buriti palm oil showed its first mass loss between 168 and 320 °C, and a second one between 320 and 471 °C, with little mass residue, a stability comparable to tonka bean. The pequi fruit oil started to degrade at 184 °C and ended its degradation at 484 °C, being stable up to 298 °C, with a mass residue of 3.88%.

The high stability of crude oils of tonka bean and buriti palm is justifiable by high contents of long-chain fatty acids (Table 2), which are the last to become degraded due to their higher molecular weight and longer chain, with more covalent bonds, making them more stable.

The thermal stability of baru oil, combined with its low acidity, high oleic acid content, and the presence of antioxidant compounds, gives it potential for culinary applications in frying processes, which reach temperatures around 180 °C and require oils highly resistant to oxidation (Abrante-Pascual et al., 2024; Zhou et al., 2024).

The DSC curves of cooling followed by heating show the temperatures and quantity of liberated or absorbed energy in the physical processes of crystallization and fusion of oil samples, when they change from liquid to solid state or vice versa (Giri and Pal, 2014). Figure 4 and Table 5 give the crystallization (cooling) and fusion (heating) events.

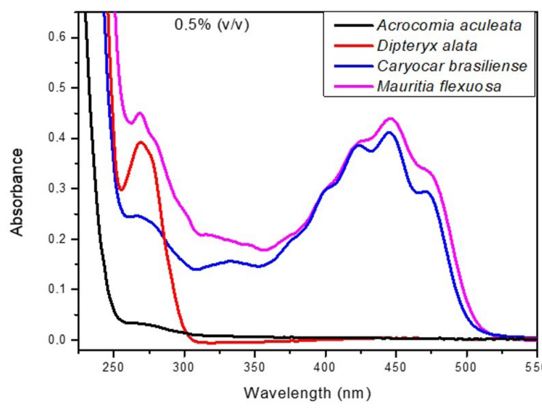

Figure 1. UV-vis absorption spectra of the crude oils of tonka bean macaw palm nut, buriti palm and pequi fruit diluted in hexane 0.5%.

Table 3. Indices of nutritional quality oils of tonka bean, macaw palm, buriti palm e pequi fruit.

Indices	Tonka bean oil	Macaw palm oil	Buriti palm oil	Pequi fruit oil
Aterogenicity	0.066	1.98	0.21	1.45
Thrombogenicity	0.242	1.15	0.49	1.47
Ratio HH	14.99	2.28	4.84	1.36

HH: hypercholesterolemic/hypocholesterolemic.

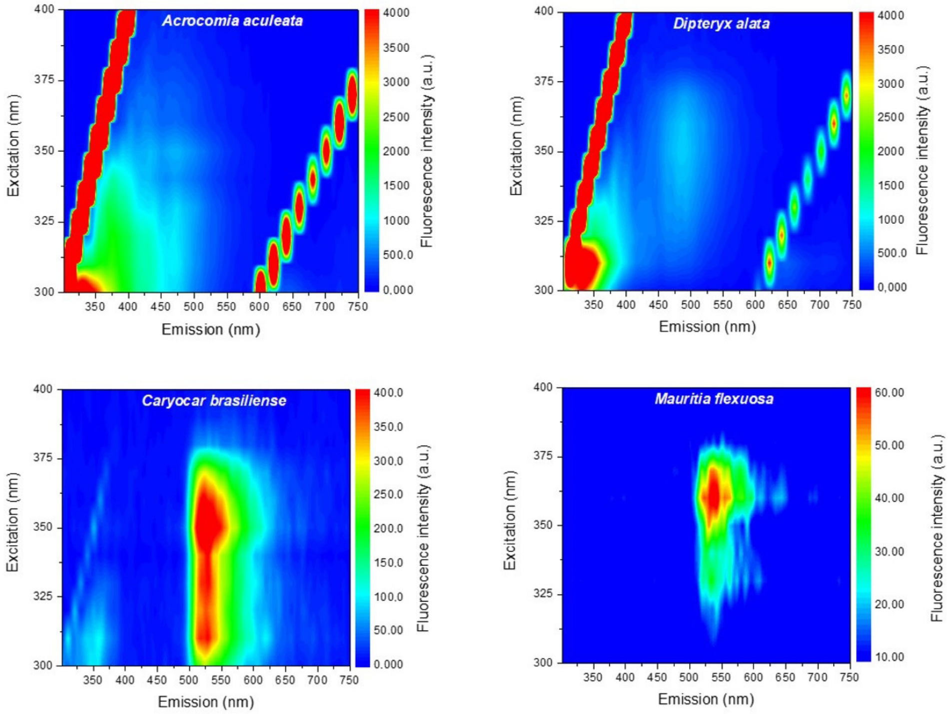

Figure 2. Emission-excitation map of the crude oils of tonka bean, macaw palm, buriti palm and pequi fruit.

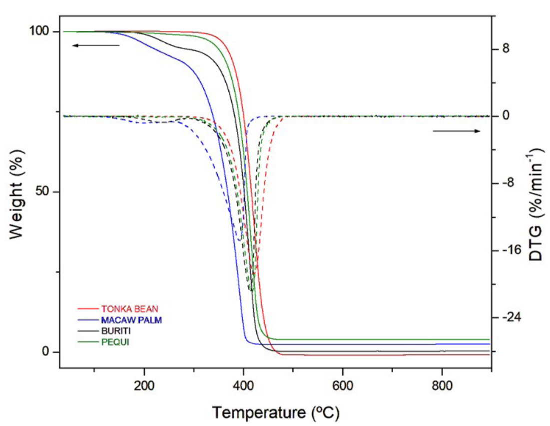

Figure 3. TG/DTG thermal decomposition curves of crude oils of tonka bean, macaw palm nut, buriti palm, and pequi fruit.

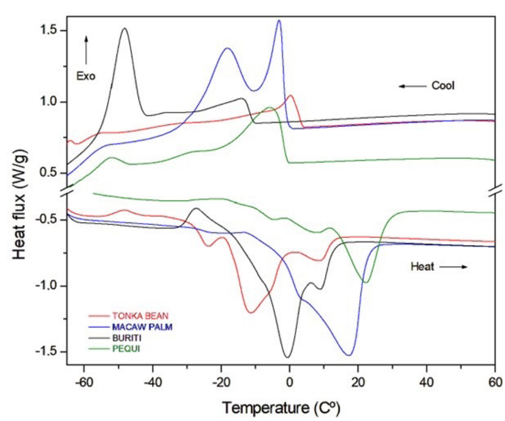

Figure 4. DSC curves if crude oils of tonka bean, macaw palm, buriti palm, and pequi palm.

In Figure 4, one can verify that the tonka bean oil crystallized at temperatures around 3.0 °C. At heating, we can visualize three events; the first at -28.10 °C, associated with the fusion of polyunsaturated fatty acids, with higher number of double bonds, had lower fusion points. The second event at -17.25 °C shows the fusion of monounsaturated fatty acids, with a medium fusion point. The third event at 3.14 °C, higher temperature than before, refers to the fusion of saturated fatty acids, which lack a double bond, and have a more stable and higher fusion point. The crude macaw palm nut oil had two crystallization events, the first referring to the saturated fatty acids and the second to the monounsaturated acids. At fusion, only one event was present, which suggests that the fusion points of saturated and monounsaturated fatty acids are close and consecutive. The buriti palm crude oil presented two crystallization events, the first signals the solidification of saturated fatty acids, and, due to its high content of monounsaturated acids (Table 2), a second peak occurred. At heating, we observed three fusion events, similar to the performance of the tonka bean oil, probably due to their similar type proportion of fatty acids. The pequi fruit crude oil had two crystallizations and two fusion events, as well as macaw palm and buriti

Table 4. TG/DTG data of the oils of tonka bean, macaw palm, buriti palm and pequi fruit.

Sample	Steps	Temperature (°C)		Δ Mass (%)	Residue (%)
		Inicial	Final		
Tonka bean oil	1st	322	480	100	0
	2nd	-	-	-	-
Macaw palm oil	1st	105	262	8.26	-
	2nd	262	431	89.24	2.35
Buriti palm oil	1st	168	320	6.77	-
	2nd	320	471	92.95	0.2
Pequi fruit oil	1st	184	298	1.08	-
	2nd	298	484	94.81	3.88

Table 5. DSC data the crude oils of tonka bean, macaw palm, buriti palm, and pequi fruit.

Samples	Event	Temperatura inicial (°C)	Temperatura do pico (°C)	Energy (J/g)
Tonka bean oil	Crystallization	3,75	0.66	4.72
	Fusion	-28.10	-24.39	3.19
	Fusion	-17.25	-11.60	31.12
	Fusion	3.14	9.45	4.06
Macaw palm nut oil	Crystallization	-1.03	-2.84	15.13
	Crystallization	-12.13	-18.24	14.11
	Fusion	-2.66	17.39	78.02
Buriti palm oil	Crystallization	-10.67	-13.09	4.00
	Crystallization	-43.55	-48.23	21.23
	Fusion	-31.61	-27.29	4.66
	Fusion	-6.63	-0.74	24.12
	Fusion	6.82	10.06	3.10
Pequi fruit oil	Crystallization	-0.82	-4.99	20.60
	Crystallization	-47.68	-52.67	2.27
	Fusion	-0.42	5.93	2.39
	Fusion	14.12	22.68	24.49

palm. The first, with little energy liberation (Table 5), is interpretable as polyunsaturated, that even in lower quantity, has a much lower fusion temperature than the other fatty acids; the second peak, is interpreted as monounsaturated and saturated acids, that can have closer fusion points, for being more stable (Meireles et al., 2022; Miyagawa et al., 2019).

4. Conclusion

The oils of tonka bean, macaw palm, buriti palm, and pequi fruit comply with the ideal values recommended for quality indices, and compare to olive oil and palm oil. The red color of the oils of buriti palm and pequi fruit indicates the presence of carotenoids, as confirmed by UV-vis and fluorescence analyses. The oils of tonka bean, buriti palm, and pequi fruit present a lipid profile that is majorly monounsaturated, whereas the macaw palm oil has a predominance of saturated fatty acids. Regarding thermal stability, the tonka bean nut oil stands out for withstanding the highest temperature of the four tested oils, indicating a potential culinary use for cooking and frying. The fatty acid profile of the macaw palm nut oil is ideal for biofuel, which would benefit the bioeconomy of the Cerrado and Pantanal.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author, [R.C.A.G.], upon reasonable request.

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