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Characterization of the essential oil extracted from the fruits of sucupira

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ABSTRACT: *Pterodon emarginatus* Vogel is a tree from the Brazilian Cerrado used in folk medicine since the 19th century; its fruit's essential oil presents several potential biological activities. This article aimed to characterize this essential oil obtained from two different sources (one extracted in the laboratory and one obtained in the Brazilian market), using GC-MS, FTIR, DSC, and TG techniques. The CG-MS analysis showed that the essential oils had different compositions; however, both had sesquiterpenes, terpenoids, and fatty alcohols. The FTIR analysis reinforced the composition data provided by the GC-MS analysis. The DSC and TG analysis showed that both essential oils were thermally stable up to 70 °C. Their vaporizing temperatures were slightly different, probably due to their different compositions. *P. emarginatus* essential oil showed similar characteristics to other essential oils and a composition that makes it a promising product for further studies.
Keywords: *Pterodon emarginatus*; stability; ethnopharmacological importance; Brazilian cerrado.

Caracterização do óleo essencial extraído dos frutos de sucupira

RESUMO: *Pterodon emarginatus* Vogel é uma árvore do Cerrado brasileiro utilizada na medicina popular desde o século XIX; o óleo essencial de seu fruto apresenta grande potencial para diversas atividades biológicas. O objetivo deste trabalho foi caracterizar esse óleo essencial, obtido de duas fontes distintas (um extraído em laboratório e outro do mercado brasileiro), por meio das técnicas GC-MS, FTIR, DSC e TG. A análise de CG-MS mostrou que os óleos essenciais apresentavam composições distintas; no entanto, ambos continham sesquiterpenos, terpenoides e álcoois graxos. A análise FTIR reforçou os dados de composição obtidos pela GC-MS. As análises DSC e TG mostraram que ambos os óleos essenciais são termicamente estáveis até 70 °C. Suas temperaturas de vaporização foram ligeiramente diferentes, provavelmente devido às suas composições distintas. O óleo essencial de *P. emarginatus* apresentou características semelhantes às de outros óleos essenciais e uma composição que o torna promissor para estudos futuros.
Palavras-chave: *Pterodon emarginatus*; estabilidade; importância etnofarmacológica; Cerrado brasileiro.

1. INTRODUCTION

Brazilian Cerrado is known for its rich and sometimes unappreciated biodiversity, being home to over 7,000 species of vascular plants, 42 % of which are endemic. Other than that, this biome houses more than 2,500 different species of animals, including mammals, birds, reptiles, amphibians, and fish, aside from insects, which are estimated to be over 90,000 different species. All that diversity makes it the richest tropical savanna in the world and one of the world's biodiversity hotspots. With a total area of around 2,000,000 km², corresponding to nearly 25 % of Brazil's territory, the Cerrado has been threatened by large-scale agricultural expansion and intensive local harvesting of forest products, making the need for a sustainable approach in the Cerrado exploration urgent (KLINK; MACHADO, 2005; PEREIRA et al., 2026).

The Pterodon genus, Fabaceae family, consists of 4 different species: *P. abruptus* Benth., *P. appariciori* Pedersoli, *P. pubescens* Benth., and *P. emarginatus* Vogel, usually known as "faveira", "sucupira", "sucupira-branca", "fava-de-sucupira", or "sucupira-lisa" (HOSCHEID; CARDOSO, 2015; VILA VERDE et al., 2018; KAWAKAMI et al., 2021). The trees from this genus are widely distributed in the Brazilian Cerrado; *P. abruptus* and *P. apparicioi* have a more limited distribution, while *P. emarginatus* and *P. pubescens are* more common, occurring in the North, northeast, southeast, and midwest regions of Brazil, which makes them the most commonly used (MACHADO et al., 2018; CARVALHO et al., 2020; WFO, 2024).

P. emarginatus Vogel has been used as a medicinal plant since the 19th century when it was first applied in the treatment of inflammations and flus, since then, its fruits have been sold in popular markets and widely used in traditional ethnomedicine as an infusion, soaked in wine, cachaça or boiling water (tea), as an anti-rheumatic, anti-inflammatory, tonic and depurative agent (ALBERTI et al., 2014; ARAÚJO et al., 2015; OLIVEIRA et al., 2017a; OLIVEIRA et al., 2017b; FARIA et al., 2017).

Essential oils have been used since ancient times by different cultures for several purposes, such as aroma, flavor, food preservation, and medicinal use (RAUT; KARUPPAYIL, 2014). These essential oils are products obtained from a natural raw material of plant origin, by steam distillation, usually hydrodistillation, and are complex mixtures of several low molecular weight compounds, mostly terpenes and terpenoids, but aromatic and aliphatic constituents can also be found (TUREK; STINTZING, 2013; RAUT; KARUPPAYIL, 2014; ISO 9235, 2021). The constitution of these essential oils may vary from one plant to another, influenced by seasonality, genetics, or weather, for instance (ALVES et al., 2013a). Generally, one or two terpene molecules present in higher concentrations in the essential oil can determine its aroma and biological properties. Essential oils in general can have a variety of therapeutic activities, such as antibacterial, antifungal, antiviral, and anticancer, among other biological activities (RAUT; KARUPPAYIL, 2014).

The essential oil extracted from *P. emarginatus* Vogel fruits can have different compositions depending on the location of the plant from which the fruits are harvested; however, sesquiterpenes like β-caryophyllene or Trans-caryophyllene, β-elemene, Spathulenol, and Germacrene-D, for instance, are suggested to be the most commonly found constituents in this essential oil (DUTRA et al., 2012; ALVES et al., 2013a; FROLDI et al., 2023). Several studies on this essential oil's biological activities describe antibacterial, immunomodulatory, gastroprotective, anti-inflammatory and antioxidant potential, making it a promising product for future studies (ROZZA; PELLIZZON, 2013; ALBERTI et al., 2014; MENDES et al., 2017; MACHADO et al., 2018; FROLDI et al., 2023).

Thus, the essential oil from *P. emarginatus* Vogel fruits has composition and stability characteristics that make it a potential raw material for the development of promising pharmaceutical, cosmetic, and/or food products. Therefore, the main goal of this work is to analyze and characterize the essential oil from the fruits of *P. emarginatus* Vogel obtained from two different sources, aiming to observe the possible differences in constitution and stability.

2. MATERIAL AND METHODS

2.1. Essential oil obtention

In order to analyze and compare the results of essential oils from different sources, two different samples of *P. emarginatus* essential oil were analyzed. The first sample was purchased from “Raiz ancestral” (PEO – essential oil obtained in the Brazilian market). According to the supplier, the *P. emarginatus* fruits were harvested from July to September, from trees located in the municipality of Cavalcante - GO. Then, the essential oil was obtained by artisanal hydrodistillation and stored in 5 mL amber glass bottles, with a shelf life of one year. The other sample was extracted in the LACQ (Quality Control Laboratory), from fruits purchased from “Arbocenter” (batch n° 00102-22).

These fruits were collected as they naturally fell from the tree, from July to September, in the municipality of Inubia Paulista – SP; then, they had their wings cut and were dried at room temperature.

The extraction process was adapted from Oliveira et al. (2017c). The fruits were ground using a coffee grinder (Hamilton beach®) and weighed on an analytical scale (approximately 150 g at room temperature of ~25 °C), then transferred to a 500 mL extraction flask where water was added in the proportion of 1:2, plant material: water (w/w). Next, the extraction by the hydrodistillation method was performed using a Clevenger-type apparatus for 4 hours, providing the essential oil (EEO – essential oil extracted in the LACQ) supernatant, which was collected using a glass pipette. The extraction was performed 6 times, and the mean dry mass yield and standard deviation were calculated.

2.2. Density

Due to the small amount of essential oil obtained in the extraction, it wasn't possible to use a pycnometer in the density test; therefore, the density of the essential oils was calculated by weighing a volume of 100 μL of the sample, measured using a micropipette, on an analytical balance, at a temperature of 25 °C, in duplicate. The density was established by Equation 1:

$$D = \frac{m}{v} \qquad (01)$$

where: D = density, in g mL^{-1}; m = mass of the sample, in g; v = volume of the sample, in mL.

2.3. Refractive index

The refractive indices of the essential oils were measured with a digital automatic Abbe refractometer (WYA-2S, Polax™), using approximately 50 μL of the sample.

2.4. Gas chromatography–mass spectrometry (GC-MS)

The essential oils were analyzed by a gas chromatograph (GC-2010 Plus - Shimadzu) attached to a mass spectrometer (GCMS-QP2010 Ultra - Shimadzu), using helium as the carrier gas (1.0 mL min^{-1}) in the following conditions: 1 μL of sample injection volume; 10:1 split; column: Rtx®-5MS 30 m 0.25 mm ID 0.25 μm Source: 250 °C; gradient: 50 °C (5 minutes), 3 °C min^{-1} until reaching 280 °C (5 minutes), interface temperature: 280 °C, ion source temperature: 250 °C, detector voltage: 1.0 kV; Full time: 86.67 minutes. The compound identification was attained from the MS library (NIST11; NIST11s).

2.5. Thermogravimetric analysis (TG curves)

The essential oils' thermal stability, moisture, and ash content were analyzed in a thermogravimetric analyzer (Shimadzu TGA-50) in a nitrogen atmosphere with a flow of 50 mL min^{-1}, from 25 to 900 ⁰C, at a heating rate of 10 ºC min^{-1}, using an alumina pan and approximately 10 mg of sample.

2.6. Differential scanning calorimetry (DSC)

A differential scanning calorimeter (DSC 60 Plus/TAC (Shimadzu)) was used to assess the essential oils and β-caryophyllene's (Sigma-Aldrich®) DSC curves. Approximately 3 mg of each sample was weighed into a sealed aluminum pan and then analyzed in a nitrogen flow rate of 50 mL min^{-1} and a heating rate of 10 ºC min^{-1}, until reaching 600 °C.

2.7. Fourier-transform infrared spectroscopy (FTIR)

The FTIR was used as an auxiliary method in the characterization of the essential oils. The infrared spectra were attained in a Fourier-transform infrared spectrophotometer (Shimadzu Iraffinity-1 – Shimadzu), using KBr tablets to support the sample, in a wavelength range between 4000 and 500 cm^{-1}, 4 cm^{-1} resolution, and 45 scans.

3. RESULTS

The essential oil extraction by hydrodistillation presented a yield of 0.138 ± 0.0291 g (w/w). Both the extracted and purchased essential oils presented a light white-yellowish color and a density of 0.878 ± 0.0020 g mL^{-1} for PEO and 0.878 ± 0.0014 g mL^{-1} for EEO. The refractive index was 1.4960 for the PEO and 1.4890 for the EEO.

Table 1 shows the compounds identified by GC-MS in both extracted and purchased essential oils, accompanied by the respective retention times, chemical class and relative percentage of the peak. The PEO presented mainly sesquiterpenes and sesquiterpenoids in its composition. The EEO was mainly constituted of sesquiterpenes, sesquiterpenoids and fatty alcohols.

Table 1. 26 main structures present in the essential oils obtained by GC-MS
Tabela 1. 26 principais estruturas presentes nos óleos essenciais obtidas por CG-MS

PEO	RT (min)	Area (%)	EEO	RT (min)	Area (%)
1,4,7,-Cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (a)	35.73	17.12	Hexadeca-2,6,10,14-tetraen-1-ol, 3,7,11,16-tetramethyl- (d)	61.97	25.07
Trans,trans-Farnesol (b)	46.34	14.58	1,5,9,9-Tetramethyl-1,4,7-cycloundecatriene (b)	36.08	16.82
Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)- (a)	37.63	8.97	9-(3,3-Dimethyloxiran-2-yl)-2,7-dimethylnona-2,6-dien-1-ol (g)	65.34	10.19
(+)-Gamma-cadinene (a)	36.88	8.04	Caryophyllene (a)	34.89	7.20
Copaene (a)	32.04	6.65	Caryophyllene oxide (b)	41.06	7.01
Tetracyclo[6.1.0.0(2,4).0(5,7)]nonane,3,3,6,6,9,9-hexamethyl-(1.alpha.,2.alpha.,4.alpha.,5.beta.,7.beta.,8.alpha.) (a)	37.04	4.95	.beta.-copaene (a)	36.83	6.23
beta-copaene (a)	37.11	4.40	Ethanone, 2-(5-furan-2-yl-[1,3,4]oxadiazol-2-ylsulfanyl)-1-(2,4,6-trimethylphenyl)- (k)	36.05	3.74
(-)-cis-beta-elemene (a)	32.96	4.12	1,11-Undecanediol (h)	35.88	3.44
2,6,10-Dodecatrienal, 3,7,11-trimethyl- (b)	46.99	2.73	Neryl acetate (d)	31.41	2.26
Caryophyllene oxide (b)	41.12	2.68	Copaene (a)	31.93	2.09
Cadina-1(10),4-diene (a)	38.71	2.28	Epoxy (1,11)humulene (l)	42.00	2.08
Farnesyl acetate (b)	50.46	2.14	4-Vinylcyclohexene dioxide (l)	35.60	1.92
.alpha.-Muurolene (a)	37.69	1.98	(-)-cis-beta-Elemene (a)	32.71	1.85
1H-Cycloprop[e]azulen-7-ol, decahydro-1,1,7-trimethyl-4-methylene-, [1ar-(1a.alpha.,4a.alpha.,7.beta.,7a.beta.,7b.alpha.)]- (b)	40.96	1.28	1-Hexadecanol (c)	51.71	1.82
.alpha.-Cubebene (a)	30.72	1.24	E-7-Tetradecenol (c)	50.92	0.77
1,5-Cadinadiene (b)	39.11	1.21	Oleyl alcohol (c)	57.61	0.72
Caryophyllene (a)	34.66	1.19	Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)- (a)	37.37	0.71
1-Hydroxy-1,7-dimethyl-4-isopropyl-2,7-cyclodecadiene (b)	40.76	0.92	Methyl salicylate (j)	23.23	0.69
.alpha.-Cadinol (b)	43.75	0.88	Acetic acid, 10,11-dihydroxy-3,7,11-trimethyl-dodeca-2,6-dienyl ester (g)	68.14	0.53
Epoxy (1,11)humulene (b)	42.03	0.61	(-)-cis-beta-Elemene (a)	37.74	0.51
.alpha.-Calacorene (a)	39.31	0.59	5E,7Z-Dodecadienyl acetate (p)	40.52	0.48
Trans-Geranylgeraniol (e)	45.91	0.49	9,12-Octadecadien-1-ol, (Z, Z)- (c)	57.42	0.44
trans,trans-Farnesol (b)	47.81	0.48	9-(3,3-Dimethyloxiran-2-yl)-2,7-dimethylnona-2,6-dien-1-ol (g)	70.32	0.42
Naphthalene, 1,2,3,4,4a,7-hexahydro-1,6-dimethyl-4-(1-methylethyl)- (a)	38.91	0.42	1,2-Dihydropyridine, 1-(1-oxobutyl)- (m)	41.53	0.38
Beta-Selinene (a)	37.18	0.34	2,7-Dimethyloxepine (n)	9.98	0.34
Boldenone (f)	41.79	0.34	Rhodium, bis[5,6-bis(.eta.2-ethenyl)cyclooctene]di-.mu.-chlorodi-, stereoisomer (o)	40.71	0.34

PEO = essential oil obtained in the Brazilian market; EEO = essential oil extracted in the laboratory; RT = Retention Time; Area = relative percentage of the peak area for each substance; chemical classes = (a) sesquiterpene; (b) sesquiterpenoid; (c) fatty alcohol; (d) monoterpenoid; (e) diterpenoid; (f) anabolic steroid; (g) terpenoid; (h) fatty diol; (i) carboxylic ester; (j) aromatic ester; (k) heteroaromatic compound; (l) epoxide; (m) nitrogenous heterocyclic compound; (n) oxepine; (o) organometallic compound; (p) fatty alcohol acetate.
PEO = óleo essencial obtido no mercado brasileiro; EEO = óleo essencial extraído em laboratório; TR = Tempo de Retenção; Área = porcentagem relativa da área do pico para cada substância; classes químicas = (a) sesquiterpeno; (b) sesquiterpenoide; (c) álcool graxo; (d) monoterpenoide; (e) diterpenoide; (f) esteroide anabólico; (g) terpenoide; (h) diol graxo; (i) éster carboxílico; (j) éster aromático; (k) composto heteroaromático; (l) epóxido; (m) composto heterocíclico nitrogenado; (n) oxepina; (o) composto organometálico; (p) acetato de álcool graxo.

The TG curves (Figure 1) showed that the mass loss happened in 2 stages for both essential oils. The first stage started at 70 °C and ended at 205 °C; the second stage started at 205 °C and ended at 405 °C. The PEO lost 86.8 % of its mass in the first stage and 10.96 % in the second stage, totaling 97.8 % of mass loss and an ash content of 2.23 %. The EEO lost 89.5 % of its mass in the first stage and 9.42 % in the second stage, totaling 98.9 % of mass loss and an ash content of 1.07 %.

The DSC curves (Figure 2) show that both essential oils presented a first broad endothermic peak, where the mean temperature was determined at the minimum point of the peak, which was 130.98 °C for PEO and 138.51 °C for EEO. Both essential oils also had a second endothermic peak, at

317.9 °C for PEO and 389.95 °C for EEO, relating to the events in the second stage of the TG analysis. The β-caryophyllene standard presented an endothermic peak at 142.51 °C.

The FTIR spectra (Figure 3) show that both essential oils had prominent peaks at 3466 cm^{-1}, between 3075 and 2866 cm^{-1}, at 1454 and 1384 cm^{-1}, and at 1634 and 887 cm^{-1}.

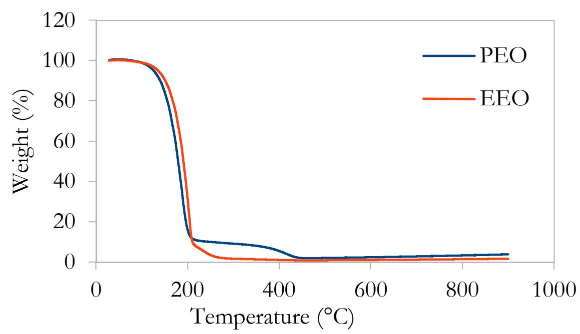

Figure 1. Thermogravimetric curves of both essential oils. PEO = essential oil obtained in the Brazilian market; EEO – essential oil extracted in the laboratory.

Figura 1. Curvas termogravimétricas de ambos óleos essenciais. PEO = óleo essencial obtido no comércio brasileiro; EEO= = óleo essencial extraído no laboratório.

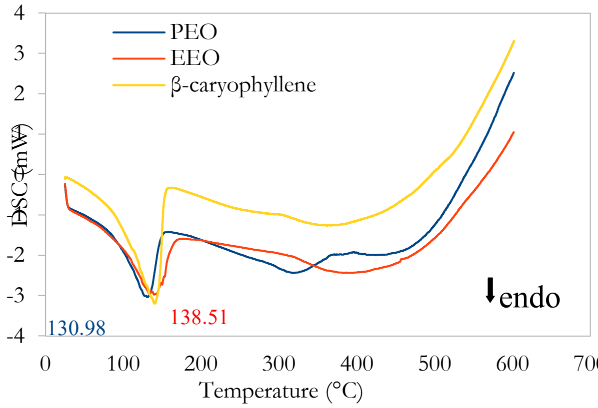

Figure 2. DSC curves of both essential oils and β-caryophyllene. PEO = essential oil obtained in the Brazilian market; EEO – essential oil extracted in the laboratory

Figura 2. Curvas DSC de ambos os óleos essenciais e do β-cariofileno. PEO = óleo essencial obtido no comércio brasileiro; EEO= = óleo essencial extraído no laboratório.

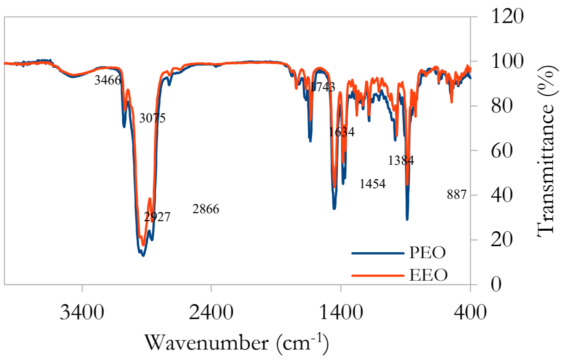

Figure 3. FTIR analysis of both essential oils. PEO = essential oil obtained in the Brazilian market; EEO = essential oil extracted in the laboratory

Figura 3. Análises de FTIR de ambos os óleos essenciais. PEO = óleo essencial obtido no comércio brasileiro; EEO= = óleo essencial extraído no laboratório.

4. DISCUSSION

The yield of 0.138 % was low when compared to the extraction yields of other authors, like Dutra et al. (2012) and Froldi et al. (2023), who had yields of 3.9 % and 1.5 % (w/w), respectively. As observed, the yield can vary from one extraction to another and might be influenced by different factors, endogenous and/or exogenous, like plant age and genotype, soil, time of harvesting, light intensity and temperature, geographic region, climate, and water availability (FERREIRA et al., 2014; MUGAO, 2024). The visual aspect of the essential oil matches the results of other authors, like Dutra et al. (2012), who extracted a light white essential oil.

The found density value is similar to that of other sesquiterpene-rich essential oils, such as the essential oil extracted from the leaves of *Psidium sobralianum*, which has a density of 0.86 g mL^{-1} (Leite et al., 2020; Macedo et al., 2022), and the essential oil obtained from *Copaifera langsdorffii*'s oil-resin, which has a density of 0.87 g mL^{-1} (LEITE et al., 2020; OLIVEIRA et al., 2017d)

The refractive index values obtained for the essential oils were a little different, which can be explained by the difference in composition of both essential oils.

The composition of the essential oils showed some differences, which is expected. Alves et al. (2013a) conducted a GC/MS analysis on the essential oil extracted from the fruits of eleven different *Pterodon emarginatus* Vogel trees across various locations. This analysis identified 34 distinct chemical substances found in varying concentrations in the essential oils, reinforcing that the chemical composition of essential oils changes from one tree to another, due to seasonality, genetics, and weather.

The high concentrations of sesquiterpenes found in the composition of both oils corroborate the results of other studies. Alves et al. (2013b) extracted an essential oil 100 % composed of different sesquiterpenes, while Alves et al. (2013a) also found high amounts of sesquiterpenes in different *P. emarginatus* Vogel essential oils, some of them with more than 90 % of sesquiterpenes.

1,4,7-Cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z-, a sesquiterpene, was the compound found in the highest amount in the PEO, while Hexadeca-2,6,10,14-tetraen-1-ol, 3,7,11,16-tetramethyl-, a monoterpenoid, had the biggest concentration in the EEO.

The EEO showed fatty alcohols in its composition, which agrees with other studies that found high amounts of fatty alcohols in the composition of other essential oils, like AVCI et al. (2014), who found a content of 73.10 % of fatty alcohols in the essential oil extracted from *Cymbocarpum erythraeum* (DC.) Boiss, or Sarma et al. (2020), who extracted the essential oil from the leaves of *Lantana camara* Linn., and found 1.64 % of fatty alcohols in it. The association of the fatty alcohols with the sesquiterpenes and other compounds in the essential oil can be very positive since fatty alcohols may present antibacterial activity (TOGASHI et al., 2007).

The compound boldenone, an anabolic steroid, was identified in the PEO. Even though it is an uncommon substance to be found in this type of sample, different authors also found it in essential oils extracted from different plants (PAUL et al., 2024; KUMAR et al., 2019). The presence of this substance may indicate contamination or an inaccurate identification by the MS library.

Rhodium, bis[5,6-bis(.eta.2-ethenyl)cyclooctene]di-.mu.-chlorodi-, stereoisomer was a substance found only in the

EEO and has very little information in the literature; however, Zeswita et al. (2016) identified it as a toxic chemical compound found in shellfish meat. On the other hand, the MS library indicated another substance with the same similarity percentage: 1,4,8-Dodecatriene,(E,E,E); wich is a long-chain hydrocarbon molecule found in fish oil (KOSASIH et al., 2021). Since there is not much information on the found substance or the fruits' background, it is very likely that its presence indicates contamination or an inaccurate identification by the MS library.

In the TG analysis, both oils started degrading and losing mass at 70 °C, which means the degradation process starts at that temperature, which is close to the thermal stability of other essential oils, like lemon essential oil (60°C) (Costés-Camargo et al., 2017), or green tea essential oil (50°C) (SHETTA et al., 2018). Usually, essential oils present a one-step mass loss in the TG analysis (Sheta et al., 2018; KringeL et al., 2017); nonetheless, the second stage of mass loss in both essential oils can be associated with the second endothermic peak in the DSC curves and might be related to the presence of compounds with different volatile behaviors (Kumar et al., 2022) or contaminants. The low thermal stability makes essential oils a little harder to work with, raising the need for ways to increase their stability, such as using the microencapsulation method, which can protect the encapsulated essential oil from heat degradation (SILVA et al., 2020; NGUYEN et al., 2021).

The first DSC endothermic peaks refer to the vaporizing temperature of the essential oils, and the second ones relate to the second stage of the TG curves, which probably occurred due to different volatile behaviors of the substances in the essential oils. After the second endothermic peak, the curve started ascending, which refers to the final decomposition process. Other than that, the absence of a peak referring to water vaporization indicates that both essential oils had no moisture content.

The different peak vaporizing temperatures for both essential oils might be related to the different compositions they have. The β-caryophyllene standard presented a vaporizing temperature of 142.51 °C, close to those of the essential oils. This result corroborates the CG-MS analysis, which found β-caryophyllene in the composition of both essential oils. Moreover, Kringel et al. (2017) established the vaporizing point of eucalyptus essential oil at 107.78 °C through DSC analysis, reinforcing the low thermal stability of essential oils.

The FTIR method is a complementary technique in the qualitative analysis of chemical compounds, used to determine functional chemical groups. Both essential oils presented very similar spectrums, with some prominent peaks, as presented in Table 2: at 3466 cm^{-1}, associated with the presence of alcohols, like the fatty alcohols found in EEO in the CG-MS analysis, and from 1640 to 1085 cm^{-1}, usually associated with β-caryophyllene, which was found in both essential oils by the GC-MS analysis. Besides that, other peaks associated with aromatic compounds and alkanes were identified, which are indicative of terpenic and terpenoid substances, also present in both essential oils (SILVERSTEIN et al., 2015; SILVA et al., 2020; DEV; MUKADAM, 2025).

Table 2. Main FTIR peaks found in the essential oils and related functional groups.
Tabela 2. Principais picos de FTIR observados nos óleos essenciais e os grupos funcionais associados.

Peak (cm^{-1})	Functional group	Compound assignment
3466	O—H axial deformation	Alcohols
3075 - 2866	=C—H axial deformation	Aromatic compounds and conjugated alkenes
1634	C=C stretching	Presence of aromatic rings
887	C—H bending	Aromatic compounds
1454	C—C—C deformation	Alkanes
1640 - 1085	C—O—C stretching	β-Caryophyllene

5. CONCLUSIONS

The *P. emarginatus* Vogel essential oil presents a diverse chemical composition containing several terpenes and terpenoids, which are described to have potential biological activities. The study of an essential oil composition is important to better understand its possible applications and predict its behavior when used in pharmaceutical and/or cosmetic products, for instance. Their low thermal stability, similar to other essential oils, is a challenge that can be solved by using this essential oil in formulations that will increase its tolerance to heat, such as microcapsules. The results presented make this essential oil a potential candidate for further investigations on its possible biological activities and the development of products and formulations containing this promising, sesquiterpene-filled essential oil.

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Data availability: Data from this study can be obtained via email upon request to the corresponding author.

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