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Volatile Profile of the *Baccharis* Genus: A Narrative Review

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Abstract

Plants synthesize a wide range of secondary metabolites, including phenolic compounds and terpenoids, which play key ecological roles and have relevant agro-industrial applications. The genus *Baccharis*, belonging to the family Asteraceae, is highly abundant in South America, particularly in Brazil, and has long been used in traditional medicine, supporting its neotropical origin. Given the growing interest in the species that compose this genus and, in their metabolites, the present study aimed to compile a structured database to support the identification of volatile compounds occurring in *Baccharis* species. A total of 158 volatile compounds were identified across 15 species, most of which belong to the subgenus *Baccharis*. Eleven compounds were observed that may serve as chemotaxonomic markers for the genus. The species most extensively studied over the past decade were *B. dracunculifolia* and *B. trimera*. Altogether, these findings highlight the metabolic potential of the *Baccharis* genus and point to new prospects for pharmaceutical and agro-industrial applications.

Keywords: South America; Asteraceae; volatile compounds; volatile compounds; chemical markers

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1. Introduction

Plants synthesize a broad range of compounds during their biochemical processes, among which secondary metabolites, particularly phenolic compounds and terpenoids, stand out. Within the terpenoid class, monoterpenes and sesquiterpenes are volatile substances associated with diverse ecological functions, especially the attraction of pollinators and natural enemies, in addition to their relevance for agro-industrial applications [1,2].

The genus *Baccharis* is one of the 196 genera of the family Asteraceae occurring in Brazil and is widely recognized in traditional communities for its medicinal properties. Although distributed across all American continents, approximately 90% of its species occur naturally in South America, a concentration that supports the idea that its center of origin lies within the Neotropical region [3–5].

Species of *Baccharis* are generally described as perennial shrubs ranging from 50 cm to 4 m in height, characterized by leaves and stems covered with a tufted indumentum composed of trichomes with adjacent basal cells, and by their dioecious nature. They exhibit substantial morphological diversity, with stems typically lacking a xylopodium, winged or striated branches, and leaves ranging from scale-like to fully developed, showing varied venation patterns and dentate margins. Their

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inflorescences are capitulescences of multiple forms, with homogamous and sexually distinct capitula (staminate or pistillate), reflecting broad ecological adaptability [6].

These species are frequently cited for their distinctive phytochemical composition, including phenolic compounds and volatile constituents, which confer a range of bioactive properties, such as antifungal [7], anticariogenic [8], antibacterial [9], antidiabetic [10], antitumoral [11], antioxidant, anti-inflammatory [12], and hepatoprotective effects [13]. These bioactivities have been widely exploited through the incorporation of oils extracted from these plants into food, pharmaceutical, and cosmetic formulations [14–17].

Considering the above, the main objective of this study was to compile a database of volatile compounds occurring in species of the genus *Baccharis*, with the purpose of supporting the identification of these metabolites.

2. Materials and Methods

This narrative review aimed to answer the following guiding question: *"What is the profile of volatile compounds reported in species of the genus Baccharis*?". Based on this inquiry, search strategies were defined for the databases ScienceDirect, PubMed, *Periódicos* CAPES, Web of Science, and Scopus.

The search was conducted using the descriptors "Chemical profile," "Volatile compounds," and "*Baccharis*," combined with the logical operator "AND," according to the structure of each platform. A 10-year time window was adopted, covering publications from 2015 to 2025. Another selection criterion concerned the analytical technique: only studies employing gas chromatography coupled with mass spectrometry (GC–MS) for compound identification were included.

To group species of the genus *Baccharis*, a dendrogram was constructed based on interspecific similarity derived from their volatile compound profiles. The analysis employed hierarchical clustering using the Jaccard dissimilarity coefficient, with binary data indicating the presence or absence of the 162 volatile compounds surveyed. Dendrograms were generated using the unweighted pair group method with arithmetic mean (UPGMA). All analyses were performed using the *vegan* package implemented in the R programming environment [18].

3. Results and Discussion

3.1. Search and Selection

Study selection was carried out through screening of titles and abstracts, considering their relevance to the research question. A total of 94 studies were identified; after removing duplicates (13) and excluding non-relevant works (69), 12 studies were included, all focused on the chemical profiles and volatile compounds of *Baccharis* species. Table 1 presents the number of studies retrieved from each database.

Fifteen species of the genus *Baccharis* were identified across the selected studies, distributed among three distinct subgenera: *Oblongifolia*, *Molina*, and *Baccharis*. *B. oblongifolia* belongs to the subgenus *Oblongifolia*, whereas *B. anomala* and *B. salicifolia* are classified within the subgenus *Molina*. The remaining species, *B. dracunculifolia*, *B. milleflora*, *B. trimera*, *B. tridentata*, *B. uncinella*, *B. dentata*, *B. calvescens*, *B. axillaris*, *B. articulata*, *B. mesoneura*, *B. myriocephala*, and *B. retusa*, belong to the subgenus *Baccharis*, which exhibited the highest species diversity in this survey.

The species with the greatest number of publications addressing volatile compound profiles was *B. dracunculifolia*, with six studies. Following this, *B. trimera* and *B. uncinella* each appeared in three studies, and *B. milleflora* was represented in two.

Among the studies focused on *B. dracunculifolia*, five were published after 2019, indicating a growing interest in the bioactive properties of its metabolites and in its close association with green propolis.

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Table 1. Search strategies used for each database.

Database	Search strategy	Articles
Science Direct	"Chemical profile" AND "Volatile compounds" AND "Baccharis"	76
PubMed	"Chemical profile" AND "Volatile compounds" AND "Baccharis"	4
CAPES	"Chemical profile" AND "Volatile compounds" AND "Baccharis"	3
Web of Science	"Chemical profile" AND "Volatile compounds" AND "Baccharis"	5
Scopus	"Chemical profile" AND "Volatile compounds" AND "Baccharis"	6

3.2. Volatile Compounds

A total of 158 volatile compounds were identified as constituents of the volatile profiles reported for the surveyed species. The monoterpenes *p*-cymene, myrcene, β-*E*-ocimene, α-pinene, β-pinene, sabinene, γ-terpinene, and α-thujene, along with the sesquiterpenes copaene, α-humulene, and γ-muurolene, were detected in 75% of the species analyzed. This recurrent composition suggests that these volatiles serve as strong indicators of the presence of plant parts and/or extracts belonging to the genus (Figure 1).

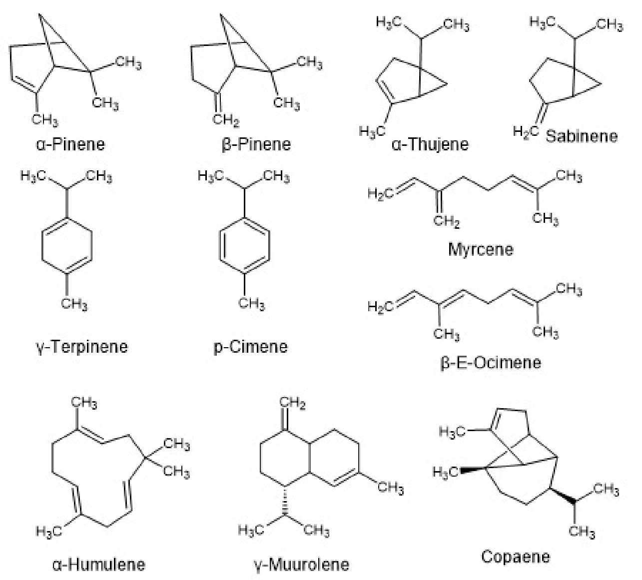

Figure 1. Volatile compounds frequently reported as constituents of the chemical profile of Baccharis species.

The occurrence of compounds such as α-pinene, β-pinene, α-thujene, sabinene, and α-humulene in the chemical profiles of plants belonging to the class *Magnoliopsida*, which includes families such as Asteraceae, Myrtaceae, and Lamiaceae [19,20], suggests a group of metabolites associated with conserved metabolic patterns maintained throughout evolutionary processes.

Within the subgenus *Oblongifolia*, 17 volatile compounds were identified, with a clear predominance of monoterpenes such as α-pinene, sabinene, myrcene, γ-terpinene, and α-terpineol (Table 2). No compound was found to be exclusive to this species when compared with the other species included in this review [21].

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Table 2. Volatile compounds reported in species of the subgenus *Oblongifolia*.

Compound	Formula	Molar Mass (g mol-1)	*Baccharis oblongifolia*
p-Cymene	$C_{10}H_{14}$	134.22	X
Myrcene	$C_{10}H_{16}$	136.23	X
β-E-Ocimene	$C_{10}H_{16}$	136.23	X
α-Pinene	$C_{10}H_{16}$	136.23	X
β-Pinene	$C_{10}H_{16}$	136.23	X
Sabinene	$C_{10}H_{16}$	136.23	X
γ-Terpinene	$C_{10}H_{16}$	136.23	X
α-Terpineol	$C_{10}H_{18}O$	154.25	X
α-Thujene	$C_{10}H_{16}$	136.23	X
Terpinen-4-ol	$C_{10}H_{18}O$	154.25	X
δ-Cadinene	$C_{15}H_{24}$	204.35	X
Copaene	$C_{15}H_{24}$	204.35	X
β-Elemene	$C_{15}H_{24}$	204.35	X
Germacrene D	$C_{15}H_{24}$	204.35	X
cis-β-Guaiene	$C_{15}H_{24}$	204.35	X
α-Humulene	$C_{15}H_{24}$	204.35	X
γ-Muurolene	$C_{15}H_{24}$	204.35	X

[1] Volatile compounds reported for *Baccharis oblongifolia* (BO), classified within the subgenus *Oblongifolia*, including molecular formula (MF) and molar mass (MM). The symbol "X" indicates the presence of the compound in the species, whereas "–" denotes its absence.

Within the subgenus *Molina*, represented by *B. anomala* and *B. salicifolia*, 34 volatile compounds were identified. Although both species belong to the same subgenus, where a certain degree of chemical similarity would be expected, only *α*-pinene and β-pinene were shared between them. This low overlap may be attributed to several factors, including chromatographic conditions, extraction methodologies, and the season or phenological stage at which plant material was collected.

Among the compounds reported for species of the *Molina* subgenus, sesquiterpenes were particularly diverse, followed by monoterpenes, especially in *B. anomala* (Table 3) [21,22].

Table 3. Volatile compounds reported in species of the subgenus *Molina*.

Compound	Formula	Molar Mass (g mol-1)	*B. salicifolia*	*B. anomala*
Styrene	C_8H_8	104.15	-	X
Phenylmethanol	C_7H_8O	108.14	-	X
Ethylidenecyclohexane	C_8H_{14}	110.2	-	X
2-Phenylpropene	C_9H_{10}	118.18	-	X
1,2,3-Trimethylbenzene	C_9H_{12}	120.19	-	X
1,2,4-Trimethylbenzene	C_9H_{12}	120.19	-	X
1,3,5-Trimethylbenzene	C_9H_{12}	120.19	-	X
Cumene	C_9H_{12}	120.19	-	X
p-Cymene	$C_{10}H_{14}$	134.22	X	-
Myrcene	$C_{10}H_{16}$	136.23	X	-
Sabinene	$C_{10}H_{16}$	136.23	X	-
α-Pinene	$C_{10}H_{16}$	136.23	X	X
α-Thujene	$C_{10}H_{16}$	136.23	X	-
β-E-Ocimene	$C_{10}H_{16}$	136.23	X	-
β-Pinene	$C_{10}H_{16}$	136.23	X	X
γ-Terpinene	$C_{10}H_{16}$	136.23	X	-
1,1,4-Trimethylidane	$C_{10}H_{16}$	160.25	-	X
1,1,5-Trimethylidane	$C_{12}H_{16}$	160.25	-	X
1,1,6-Trimethylidane	$C_{12}H_{16}$	160.25	-	X

Cyclohexylbenzene	$C_{12}H_{16}$	160.25	-	X
Trimethylidane	$C_{12}H_{16}$	160.25	-	X
trans-Calamenene	$C_{15}H_{22}$	202.33	-	X
α-Humulene	$C_{15}H_{24}$	204.35	X	-
β-Elemene	$C_{15}H_{24}$	204.35	X	-
Bicyclogermacrene	$C_{15}H_{24}$	204.35	X	-
Copaene	$C_{15}H_{24}$	204.35	X	-
Germacrene D	$C_{15}H_{24}$	204.35	X	-
Modheph-2-ene	$C_{15}H_{24}$	204.35	X	-
β-Cubebene	$C_{15}H_{24}$	204.35	X	-
δ-Cadinene	$C_{15}H_{24}$	204.35	X	-
1-Epi-cubenol	$C_{15}H_{26}O$	222.37	X	-
Viridiflorol	$C_{15}H_{26}O$	222.37	X	-
α-Cadinol	$C_{15}H_{26}O$	222.37	X	-
α-Muurolol	$C_{15}H_{26}O$	222.37	X	-

[1] Volatile compounds reported in Baccharis salicifolia (BS) and Baccharis anomala (BA), both classified within the subgenus Molina, accompanied by their molecular formula (MF) and molar mass (MM). The symbol "X" indicates the presence of the compound in the respective species, whereas "–" denotes its absence.

The most extensively studied subgenus in terms of volatile compounds was the subgenus *Baccharis*, comprising 12 of the surveyed species and totaling 148 compounds, with a predominance of terpenoids—particularly monoterpenes and sesquiterpenes (Table 4). Among the compounds identified, β-pinene, *α*-thujene, sabinene, *α*-humulene, and γ-muurolene were detected in all species of this group.

In *B. calvescens*, guaiol was the only compound reported as exclusive among the species of the subgenus [21]. *B. trimera* exhibited exclusivity for β-isophorone, carquejol acetate, and *trans*-pinocarvyl acetate [21]. *B. mesoneura* showed the singular presence of salviol-4(14)-en-1-one, whereas *B. milleflora* was distinguished by the exclusive occurrence of *α*-acorenol [21,23].

In *B. uncinella*, the following compounds were identified as exclusive constituents: *α*-felandrene, (Z)-β-ocimene, nopinone, pinocarvone, safranal, (E)-sabinol, (Z)-carveol, (E)-tagetone, (E)-β-ionone, cadalene, (E)-calamen-10-ol, iso-italicene epoxide, and cubene [23–25].

In *B. dracunculifolia*, the exclusive constituents identified were acetophenone, δ-isopulegol, dihydrotagetone, methyl eugenol, *α*-curcumene, *α*-elemene, *α*-bourbonene, ylangene, δ-elemene, dauca-5,8-diene, isobicyclogermacrenal, ledene oxide, cedrene-13-en-8-ol, germacran-8-4-ol, cabreuva oxide B, β-copaen-4*α*-ol, khusimol, *trans*-nerolidol, junenol, *α*-muurolol, β-oplopenone, phytol, and heptacosane. The high diversity of exclusive constituents reported for *B. dracunculifolia* can be explained by the large number of studies focusing on this species [25–31].

In *B. retusa*, the exclusive constituents identified were 2-hexenal, hexanal, (E)-3-hexen-1-ol, 1-hexanol, *n*-cymene, 3-carene, *α*-ocimene, β-damascenone, β-eudesmene, and β-cadinene [32]. In *B. dentata*, the exclusive compounds were *n*-nonanal, carvone, *α*-campholenal, (E)-pinocarveol, (E)-verbenol, geranial, *α*-calacorene, (E)-muurola-4(14),5-diene, and δ-amorphene [23].

Table 4. Volatile compounds reported in species of the subgenus *Molina*.

Compound	**MF**	**MM (g mol[-1])**	BM	BT	BMY	BTR	BD	BAX	BAR	BME	BR	BDR	BC	BU
2-Hexenal	$C_6H_{10}O$	98.14	-	-	-	-	-	-	-	-	X	-	-	-
Hexanal	$C_6H_{12}O$	100.16	-	-	-	-	-	-	-	-	X	-	-	-
(E)-3-Hexen-1-ol	$C_6H_{12}O$	100.16	-	-	-	-	-	-	-	-	X	-	-	-
1-Hexanol	$C_6H_{14}O$	102.17	-	-	-	-	-	-	-	-	X	-	-	-
Acetophenone	C_8H_8O	120.15	-	-	-	-	-	-	-	-	-	X	-	-
p-Cymenene	$C_{10}H_{12}$	132.2	-	-	-	-	X	-	-	-	-	-	-	X
p-Methylacetophenone	$C_9H_{10}O$	134.17	-	-	-	-	X	-	-	-	-	-	-	X
m-Cymene*	$C_{10}H_{14}$	134.22	-	-	-	-	-	-	-	-	X	-	-	-
p-Cymene	$C_{10}H_{14}$	134.22	X	X	X	-	X	X	X	X	-	X	X	X

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δ-3-Carene	$C_{10}H_{16}$	136.23	-	-	-	-	-	-	-	-	X	-	-	-
α-Ocimene	$C_{10}H_{16}$	136.23	-	-	-	-	-	-	-	-	X	-	-	-
α-Fenchene (if intended; otherwise *α*-Felandrene kept as submitted)	$C_{10}H_{16}$	136.23	-	-	-	-	-	-	-	-	-	-	-	X
(*Z*)-*β*-Ocimene	$C_{10}H_{16}$	136.23	-	-	-	-	-	-	-	-	-	-	-	X
cis-*β*-Ocimene	$C_{10}H_{16}$	136.23	-	X	-	-	-	-	-	-	-	X	-	-
Terpinolene	$C_{10}H_{16}$	136.23	-	-	-	-	X	-	-	-	X	X	-	-
α-Terpinene	$C_{10}H_{16}$	136.23	-	-	-	-	X	-	-	-	-	X	-	X
β-Felandrene	$C_{10}H_{16}$	136.23	X	X	-	X	-	-	-	-	-	-	-	X
Camphene	$C_{10}H_{16}$	136.23	-	X	-	X	X	-	-	-	X	-	-	X
α-Pinene	$C_{10}H_{16}$	136.23	X	X	X	X	-	X	X	X	X	X	X	X
Myrcene	$C_{10}H_{16}$	136.23	X	X	X	-	X	X	X	X	X	X	X	X
γ-Terpinene	$C_{10}H_{16}$	136.23	X	X	X	-	X	X	X	X	X	X	X	X
β-*E*-Ocimene	$C_{10}H_{16}$	136.23	X	X	X	X	X	X	X	X	-	X	X	X
β-Pinene	$C_{10}H_{16}$	136.23	X	X	X	X	X	X	X	X	X	X	X	X
α-Thujene	$C_{10}H_{16}$	136.23	X	X	X	X	X	X	X	X	X	X	X	X
Sabinene	$C_{10}H_{16}$	136.23	X	X	X	X	X	X	X	X	X	X	X	X
β-Isophorone	$C_9H_{14}O$	138.21	-	X	-	-	-	-	-	-	-	-	-	-
δ-Isopulegol	$C_9H_{14}O$	138.21	-	-	-	-	-	-	-	-	-	X	-	-
Nopinone	$C_9H_{14}O$	138.21	-	-	-	-	-	-	-	-	-	-	-	X
Cryptone	$C_9H_{14}O$	138.21	-	X	-	-	X	-	-	-	-	-	-	X
n-Nonanal	$C_9H_{18}O$	142.24	-	-	-	-	X	-	-	-	-	-	-	-
Cuminaldehyde	$C_{10}H_{12}O$	148.2	-	-	-	-	X	-	-	-	-	-	-	X
Pinocarvone	$C_{10}H_{14}O$	150.22	-	-	-	-	-	-	-	-	-	-	-	X
Safranal	$C_{10}H_{14}O$	150.22	-	-	-	-	-	-	-	-	-	-	-	X
Carvone	$C_{10}H_{14}O$	150.22	-	-	-	-	X	-	-	-	-	-	-	-
Myrtenal	$C_{10}H_{14}O$	150.22	-	-	-	-	X	-	-	-	-	X	-	-
Verbenone	$C_{10}H_{14}O$	150.22	-	-	-	-	X	-	-	-	-	-	-	X
α-Campholenal	$C_{10}H_{16}O$	152.23	-	-	-	-	X	-	-	-	-	-	-	-
(*E*)-Pinocarveol	$C_{10}H_{16}O$	152.23	-	-	-	-	X	-	-	-	-	-	-	-
(*E*)-Sabinol	$C_{10}H_{16}O$	152.23	-	-	-	-	-	-	-	-	-	-	-	X
(*E*)-Verbenol	$C_{10}H_{16}O$	152.23	-	-	-	-	X	-	-	-	-	-	-	-
(*Z*)-Carveol	$C_{10}H_{16}O$	152.23	-	-	-	-	-	-	-	-	-	-	-	X
Geranial	$C_{10}H_{16}O$	152.23	-	-	-	-	X	-	-	-	-	-	-	-
(*E*)-Tagetone	$C_{10}H_{16}O$	152.23	-	-	-	-	-	-	-	-	-	-	-	X
Myrtenol	$C_{10}H_{16}O$	152.23	-	-	-	-	X	-	-	-	-	X	-	-
Camphor	$C_{10}H_{16}O$	152.23	-	X	-	-	X	-	-	-	-	-	-	-
p-Menthadienol	$C_{10}H_{16}O$	152.23	-	-	-	-	X	-	-	-	-	-	-	X
(*E*)-Carveol	$C_{10}H_{16}O$	152.23	-	-	-	-	X	-	-	-	-	-	-	X
Perillyl alcohol	$C_{10}H_{16}O$	152.23	-	-	-	-	X	-	-	-	-	-	-	X
Dihydrotagetone	$C_{10}H_{18}O$	154.25	-	-	-	-	-	-	-	-	-	X	-	-
Citronellal	$C_{10}H_{18}O$	154.25	-	-	-	-	X	-	-	-	-	-	-	X
Borneol	$C_{10}H_{18}O$	154.25	-	-	-	-	X	-	-	-	-	-	-	X
(*Z*)-Piperitol	$C_{10}H_{18}O$	154.25	-	-	-	-	X	-	-	-	-	-	-	X
Geraniol	$C_{10}H_{18}O$	154.25	-	-	-	-	X	-	-	-	-	-	-	X
Linalool	$C_{10}H_{18}O$	154.25	-	-	-	-	X	-	-	-	X	X	-	-
Terpinen-4-ol	$C_{10}H_{18}O$	154.25	X	-	-	-	-	-	X	X	-	X	X	X
α-Terpineol	$C_{10}H_{18}O$	154.25	X	-	-	-	X	-	X	X	X	X	X	X
Methyl eugenol	$C_{11}H_{14}O_2$	178.23	-	-	-	-	-	-	-	-	-	X	-	-
β-Damascenone	$C_{13}H_{18}O$	190.28	-	-	-	-	-	-	-	-	X	-	-	-
Carquejol acetate	$C_{12}H_{15}O_2$	191.25	-	X	-	-	-	-	-	-	-	-	-	-
(*E*)-*β*-Ionone	$C_{13}H_{20}O$	192.3	-	-	-	-	-	-	-	-	-	-	-	X
trans-Pinocarvyl acetate	$C_{12}H_{18}O_2$	194.27	-	X	-	-	-	-	-	-	-	-	-	-
Bornyl acetate	$C_{12}H_{18}O_2$	196.29	-	X	-	X	-	-	-	-	-	-	-	-
Cadalene	$C_{15}H_{18}$	198.3	-	-	-	-	-	-	-	-	-	-	-	X
α-Calacorene	$C_{15}H_{20}$	200.32	-	-	-	-	X	-	-	-	-	-	-	-

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α-Curcumene	$C_{15}H_{22}$	202.33	-	-	-	-	-	-	-	-	-	X	-	-
trans-Calamenene	$C_{15}H_{22}$	202.33	-	-	X	-	-	-	X	-	-	-	-	-
ar-Curcumene	$C_{15}H_{22}$	202.33	X	-	-	-	-	-	-	-	-	-	-	X
β-Eudesmene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	X	-	-	-
β-Cadinene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	X	-	-	-
α-Elemene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	-	X	-	-
α-Bourbonene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	-	X	-	-
Ylangene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	-	X	-	-
δ-Elemene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	-	X	-	-
Dauca-5,8-diene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	-	X	-	-
(*E*)-Muurola-4(14),5-diene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	-	-	-
δ-Amorphene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	-	-	-
Aromadendrene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	X	X	-	-
α-Gurjunene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	-	X	-	X
δ-Amorphene (duplicate preserved)	$C_{15}H_{24}$	204.35	X	-	-	-	-	-	-	-	-	-	-	X
α-Longipinene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	-	-	X
2-Epi-*β*-Funebrene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	-	-	X
β-Gurjunene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	-	-	X
α-(*E*)-Bergamotene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	-	-	X
(*E*)-*β*-Farnesene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	-	-	X
Germacrene A	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	-	-	X
Allo-aromadendrene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	X	X	-	-
α-Muurolene	$C_{15}H_{24}$	204.35	-	-	-	-	-	-	-	-	X	X	-	X
β-Copaene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	X	-	X
α-Cubebene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	X	-	X
trans-*α*-Bergamotene	$C_{15}H_{24}$	204.35	X	-	-	X	-	-	-	-	-	-	-	X
(*E*,*E*)-*α*-Farnesene	$C_{15}H_{24}$	204.35	X	-	-	X	-	-	-	-	-	-	-	X
β-Cubebene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	X	-	-	-	X
(*E*)-Cadina-1(6)-4-diene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	-	X	-	X
β-Guaiene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	X	X	-	X
Ledene	$C_{15}H_{24}$	204.35	-	-	X	-	X	-	-	-	X	-	-	X
γ-Cadinene	$C_{15}H_{24}$	204.35	-	-	-	-	X	-	-	-	X	X	-	X
α-Amorphene	$C_{15}H_{24}$	204.35	X	X	-	X	-	-	-	-	-	-	-	X
cis-*β*-Guaiene	$C_{15}H_{24}$	204.35	-	-	-	-	-	X	X	-	-	-	X	X
β-Elemene	$C_{15}H_{24}$	204.35	-	X	-	-	X	X	X	-	X	X	X	X
Germacrene D	$C_{15}H_{24}$	204.35	-	-	-	-	X	X	X	X	X	X	X	X
Bicyclogermacrene	$C_{15}H_{24}$	204.35	X	X	-	X	X	-	-	X	X	X	-	X
δ-Cadinene	$C_{15}H_{24}$	204.35	X	X	-	X	X	X	-	X	-	X	-	X
Copaene	$C_{15}H_{24}$	204.35	-	-	X	-	X	X	X	X	X	X	X	X
α-Humulene	$C_{15}H_{24}$	204.35	X	X	X	X	X	X	X	X	X	X	X	X
γ-Muurolene	$C_{15}H_{24}$	204.35	X	X	X	X	X	X	X	X	X	X	X	X
Tetradecanal	$C_{14}H_{28}O$	212.37	-	X	-	-	-	-	-	-	-	-	-	X
Isobicyclogermacrenal	$C_{15}H_{22}O$	218.33	-	-	-	-	-	-	-	-	-	X	-	-
(*E*)-Calamen-10-ol	$C_{15}H_{22}O$	218.33	-	-	-	-	-	-	-	-	-	-	-	X
Ledene oxide	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	-	-	X	-	-
Isospathulenol	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	-	X	-	-	-
Cedrene-13-en-8-ol	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	-	-	X	-	-
Germacran-*δ*-4-ol	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	-	-	X	-	-
Cabreuva oxide B	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	-	-	X	-	-
β-Copaen-4*α*-ol	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	-	-	X	-	-
Khusimol	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	-	-	X	-	-
Salviol-4(14)-en-1-one	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	X	-	-	-	-
Iso-italicene epoxide	$C_{15}H_{22}O$	220.35	-	-	-	-	-	-	-	-	-	-	-	X
Eudesma-4(15),7-dien-1*β*-ol	$C_{15}H_{22}O$	220.35	X	-	-	-	-	-	-	-	-	-	-	X

Aromadendrene oxide	$C_{15}H_{22}O$	220.35	X	X	-	-	-	-	-	-	-	-	-	-
Spathulenol	$C_{15}H_{22}O$	220.35	-	X	-	-	-	-	-	-	-	X	-	-
Humulene epoxide II	$C_{15}H_{22}O$	220.35	X	-	-	-	-	-	-	X	-	-	X	X
Germacra-4(15),5,10(14)-trien-1*α*-ol	$C_{15}H_{22}O$	220.35	X	X	-	-	-	-	-	-	-	X	-	X
Isospathulenol (duplicate preserved)	$C_{15}H_{22}O$	220.35	X	X	X	-	-	-	X	-	-	-	X	X
Caryophyllene oxide	$C_{15}H_{22}O$	220.35	X	X	X	X	-	X	-	X	-	X	X	X
trans-Nerolidol	$C_{15}H_{26}O$	222.37	-	-	-	-	-	-	-	-	-	X	-	-
Junenol	$C_{15}H_{26}O$	222.37	-	-	-	-	-	-	-	-	-	X	-	-
α-Muurolol	$C_{15}H_{26}O$	222.37	-	-	-	-	-	-	-	-	-	X	-	-
Guaiol	$C_{15}H_{26}O$	222.37	-	-	-	-	-	-	-	-	-	-	X	-
α-Acorenol	$C_{15}H_{26}O$	222.37	X	-	-	-	-	-	-	-	-	-	-	-
Cubenol	$C_{15}H_{26}O$	222.37	-	-	-	-	-	-	-	-	-	-	-	X
Rosifoliol	$C_{15}H_{26}O$	222.37	-	-	X	-	-	-	X	-	-	-	-	X
Bulnesol	$C_{15}H_{26}O$	222.37	X	-	-	-	X	-	-	-	-	-	-	X
α-Epi-cadinol	$C_{15}H_{26}O$	222.37	-	-	X	-	-	-	X	-	X	X	-	-
t-Cadinol	$C_{15}H_{26}O$	222.37	X	X	-	X	-	-	-	-	-	-	-	X
Cubeban-11-ol	$C_{15}H_{26}O$	222.37	-	-	X	-	-	-	-	-	-	X	X	X
β-Selinene	$C_{15}H_{26}O$	222.37	-	X	-	X	X	X	-	-	-	-	X	-
Palustrol	$C_{15}H_{26}O$	222.37	X	X	-	-	-	-	X	-	-	X	-	X
Ledol	$C_{15}H_{26}O$	222.37	X	X	-	-	X	-	-	-	-	X	-	X
1-Epi-cubenol	$C_{15}H_{26}O$	222.37	X	-	X	-	-	-	-	-	-	X	X	X
β-Eudesmol	$C_{15}H_{26}O$	222.37	X	X	X	-	-	X	-	-	-	-	X	X
Globulol	$C_{15}H_{26}O$	222.37	-	X	-	-	X	-	X	X	X	X	-	X
Viridiflorol	$C_{15}H_{26}O$	222.37	X	X	X	-	-	X	X	-	X	X	X	X
α-Cadinol	$C_{15}H_{26}O$	222.37	X	X	X	-	-	X	X	X	-	X	X	X
Epi-*α*-Muurolol	$C_{15}H_{26}O$	222.37	X	X	X	-	-	X	X	X	-	X	X	X
Murolan-3,9(11)-diene-10-peroxide	$C_{15}H_{24}O_2$	236.35	-	-	-	-	X	-	-	-	-	X	-	X
β-Oplopenone	$C_{15}H_{26}O_2$	238.37	-	-	-	-	-	-	-	-	-	X	-	-
Neophytadiene	$C_{20}H_{38}$	278.5	X	X	-	-	-	-	-	-	-	-	-	-
Phytol	$C_{20}H_{40}O$	296.5	-	-	-	-	-	-	-	-	-	X	-	-
Heptacosane	$C_{27}H_{56}$	380.7	-	-	-	-	-	-	-	-	-	X	-	-

[1] Volatile compounds reported in *Baccharis milleflora* (BM), *Baccharis mesoneura* (BME), *Baccharis retusa* (BR), *Baccharis articulata* (BAR), *Baccharis axillaris* (BAX), *Baccharis myriophoella* (BMY), *Baccharis trimera* (BT), *Baccharis anomala* (BA), *Baccharis salicifolia* (BS), *Baccharis dentata* (BD), *Baccharis oblongifolia* (BO), *Baccharis calvescens* (BC), *Baccharis dracunculifolia* (BDR), *Baccharis uncinella* (BU), and *Baccharis tridentata* (BTR), all classified within the subgenus Baccharis, together with their respective molecular formulas (MF) and molar masses (MM). The molecular formula (MF) represents the chemical composition of each compound, and the molar mass (MM) is expressed in grams per mole (g/mol). The symbol "X" indicates the presence of the compound in the respective species, whereas "–" denotes its absence.

3.3. Cluster Analysis

All volatile compounds identified in the selected studies were subjected to hierarchical clustering analysis (UPGMA) to investigate patterns of similarity among *Baccharis* species (Figure 2). The dendrogram was constructed using the Jaccard dissimilarity coefficient, based on the presence or absence of 159 volatile compounds. The clustering results revealed the formation of at least five distinct chemical profiles among the evaluated species.

The first group consisted exclusively of *B. salicifolia*, indicating a unique chemical profile. The second cluster brought together *B. dentata*, *B. dracunculifolia*, and *B. uncinella*. The third group consisted of *B. retusa*, which exhibited a volatile composition distinct from the remaining species. The fourth cluster encompassed a larger set of species, *B. calvescens*, *B. axillaris*, *B. articulata*, *B. oblongifolia*, *B. myriocephala*, *B. mesoneura*, and *B. anomala*, suggesting close chemical similarity among them.

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Finally, the fifth group included *B. tridentata*, *B. milleflora*, and *B. trimera*, which displayed similar volatile profiles.

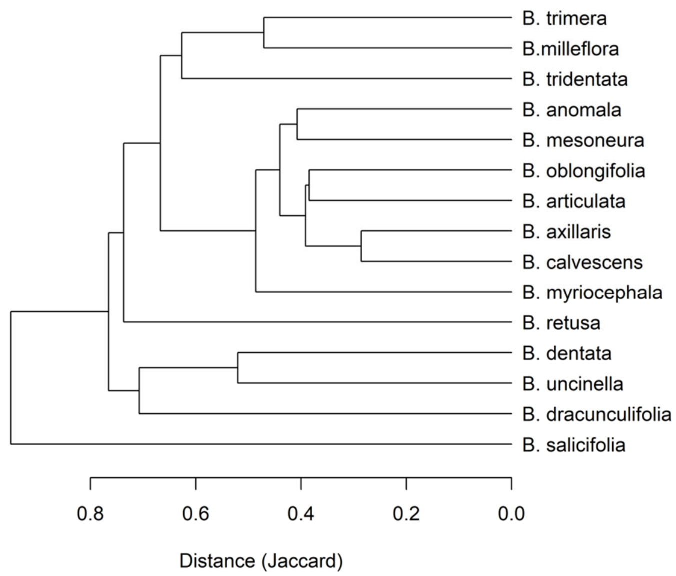

Figure 2. Dendrogram obtained through hierarchical clustering analysis of the volatile extract composition of the surveyed *Baccharis* species.

Although organisms classified as closely related often exhibit similar chemical characteristics due to shared evolutionary ancestry, the available data are not sufficiently comprehensive to conclusively confirm taxonomic proximity. Nonetheless, the findings suggest a probable evolutionary relationship among the groups observed [33].

5. Conclusions

Given the number of studies identified, species belonging to the subgenus *Baccharis*, particularly *B. dracunculifolia* and *B. trimera*, stand out in comparison with the others surveyed. The presence of α-pinene, β-pinene, α-thujene, sabinene, myrcene, γ-terpinene, copaene, α-humulene, γ-muurolene, *p*-cymene, and β-*E*-ocimene in their chemical profiles may serve as potential biomarkers indicating the contribution of *Baccharis* species to the composition of plant-derived products. Although these volatiles constitute strong indicators, broader and more comprehensive studies are needed to refine and validate these patterns, given the considerable diversity of species classified within the genus.

In the composition of volatile profiles, monoterpenes and sesquiterpenes are the phytochemical classes most frequently reported, with *B. dracunculifolia* exhibiting the highest number of these compounds in its volatile profile.

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Abbreviations

The following abbreviations are used in this manuscript:

MF	Molecular Formula
MM	Molar Mass
BM	*Baccharis milleflora*
BME	*Baccharis mesoneura*
BR	*Baccharis retusa*
BAR	*Baccharis articulata*
BAX	*Baccharis axillaris*
BMY	*Baccharis myriophoella*
BT	*Baccharis trimera*
BA	*Baccharis anomala*
BS	*Baccharis salicifolia*
BD	*Baccharis dentata*
BO	*Baccharis oblongifolia*
BC	*Baccharis calvescens*
BDR	*Baccharis dracunculifolia*
BU	*Baccharis uncinella*
BTR	*Baccharis tridentata*

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