Chapter 11
Flavonoids of *Baccharis*

Simone dos Santos Grecco, Deborah Pelosi Sessa, and João Henrique Ghilardi Lago

Abstract Despite more than 400 species of *Baccharis* occurring worldwide, only less than 20% of the species have chemically been studied. In the *Baccharis* genus, within terpenes and other phenolic compounds (see Chaps. 12 and 13), flavonoids are largely accumulated as aglycone, being apigenin, genkwanin, hispidulin, kaempferol (flavones), quercetin (flavonol), naringenin, sakuranetin (flavanones), and others widely distributed. Additionally, some flavonoid glycosides such as quercitrin, rutin, and others are also found, but in minor frequency. Flavonoids are compounds with a basic skeleton of 15 carbons (C_6-C_3-C_6) arranged in two aromatic rings linked through a three-carbon moiety. The oxidation degree of the C_3 moiety is directly related to the classification of flavonoids into flavanones, flavones, isoflavones, flavanonols, and flavonols. With respect to biological activity, flavonoids from *Baccharis* display a significant antioxidant potential, especially for the capacity of suppression of ROS formation, ROS scavenging, and upregulation of antioxidant defenses. In this chapter, the distribution of flavonoids in *Baccharis* is so justified through this antioxidant effect since those species are inserted in areas with direct incidence of sunrays, such as in montane savannas. In addition, flavonoids display hepatoprotective, antimicrobial, anti-inflammatory, antitumoral, antiviral, and other activities. In this chapter, the occurrence and distribution of flavonoids in *Baccharis* species are discussed, as well as their biosynthesis and biological aspects.

Keywords Biological activity · Biosynthesis · Flavonoid distribution · Modulation of redox balance · Structure and composition

1 Introduction

Although more than 400 *Baccharis* species are distributed worldwide, only a reduced number of plants belonging to this genus were chemically and/or biologically investigated. Among the chemical compounds present in these species, the

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G. W. Fernandes et al. (eds.), *Baccharis*,
https://doi.org/10.1007/978-3-030-83511-8_11

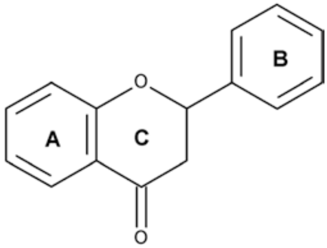


Fig. 11.1 Basic skeleton of a flavonoid

occurrence of flavonoids is reported in about 15% of *Baccharis* species (Campos et al. 2016). Flavonoids are a class of phenolic compounds, widely distributed within the kingdom Plantae, with a basic skeleton of 15 carbons (Fig. 11.1) arranged as two aromatic rings (A and B) connected by a three-carbon moiety (C_6-C_3-C_6).

The classification of flavonoids is directly related to the degree of oxidation of the C_3 portion. Flavonoids can be classified into flavanones, flavononols, flavones, isoflavones, flavonols, catechins, and anthocyanidins.

2 Biosynthesis

Secondary metabolites, also known as special metabolites, are substances from natural sources that do not participate in the essential functions of these organisms (reproduction, growth, or development). Most are substances produced in processes of interaction between plants and the environment in which they are inserted. It is important to note that the production of secondary metabolites is also associated with the various conditions to which plant species are subjected. Since these substances are produced to benefit these individuals, depending on the environment surrounding them, it acts as protection against the action of predators, coloring and volatiles agents, attracting pollinators, and also as competition agents among plants in the same habitat. Therefore, the production of these metabolites is fundamental in the maintenance of these species (Dewick 2009).

Besides being responsible for the production of substances that act with different functions in the interaction of these plant species and the environment, which are inserted, the secondary metabolism is also responsible for providing the majority of natural products with pharmacological activity. The secondary metabolism acts as substrates originating from the metabolic pathways that form the primary metabolism (photosynthesis, glycolysis, and Krebs/ citric acid cycle). These substrates are involved in different metabolic pathways, responsible for the synthesis of several classes of secondary metabolites.

Flavonoids are considered mixed pathway metabolites, being synthesized from precursors of two metabolic routes; shikimic acid (shikimate) and acetate-malonate. From the glycolysis process, the synthesis of phosphoenylpyruvate, together with erythrose-4-phosphate from the pentose-phosphate pathway, is responsible for the synthesis of shikimic acid. In glycolysis, phosphoenylpyruvate, through the enzyme pyruvate kinase, transfers the phosphate ion to a molecule of ADP, generating pyruvate and ATP. This pyruvate is responsible for the synthesis of acetyl-CoA (acetyl coenzyme A). From the shikimic acid path, *p*-coumaric acid (4-coumaric acid) is obtained, resulting from the ammonia elimination from L-phenylalanine side chain (precursors of the C_6-C_3 portions), and precursor of *p*-coumaric alcohol. The elimination of ammonia occurs in the presence of PAL (phenylalanine ammonia lyase) into cinnamic acid, which is converted into *p*-coumaric acid by direct hydroxylation, in the presence of cinnamate-4-hydroxylase (C4H), which is converted to 4-hydroxycinnamoyl-CoA by the 4-coumarate CoA ligase (4CL), by a process known as the general pathway to the formation of phenylpropanoids. The enzyme involved in the consensation process of malonyl-CoA units to form flavonoids is chalcone synthase, through the acetyl-CoA carboxylase (ACC) mediates carboxylation reaction. Therefore, the formation of flavonoids (Fig. 11.2) occurs from 4-hydroxycinnamoyl-CoA units, derived from the pathway of shikimic acid with the addition of malonyl-CoA units (for chain elongation), the route of acetate-malonate (Davies and Schwinn 2006; Dewick 2009).

After the addition of malonyl-CoA units, two pathways could be involved in the formation of different metabolites – flavonoids or stilbenes (e.g., resveratrol). After the formation of the polyketide, different enzymes are involved in aldol or Claisen type condensations to form aromatic ring A. For the formation of flavonoids, the enzyme involved in the condensation process of malonyl-CoA units is chalcone synthase. Chalcones are the precursors of flavonoids (I), followed by enolization (II) of the polyketide (Fig. 11.3).

For the synthesis of flavonoids, chalcones undergo a nucleophilic attack reaction of the OH group to the α,β-unsaturated ketone, forming a heterocyclic ring (C-ring) yielding flavanones. Acidic environments may favor the synthesis of flavanones,

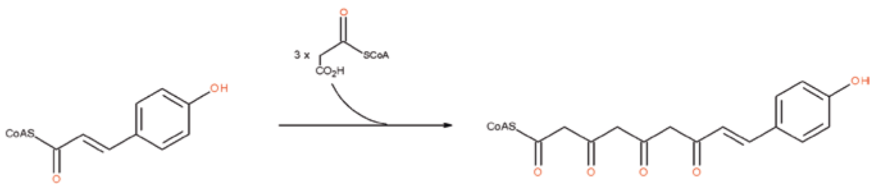


Fig. 11.2 Formation of the polyketide side chain, precursor of flavonoids, by acetate-malonate route

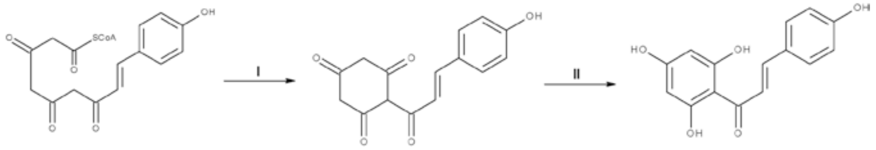


Fig. 11.3 Steps for chalcone biosynthesis from polyketide side chain

while alkaline environments favor the production of chalcones. However, it is worth emphasizing that in nature, these processes occur under very specific conditions, in the presence of stereospecific enzymes that prevent the formation of enantiomers. From the flavanones, a large variety of flavonoids can be synthesized, such as flavones, flavonols, and anthocyanidins (Davies and Schwinn 2006).

According to the basic skeleton of flavonoids, the variations between the different classes of flavonoids are related to the oxygenations and substituents of rings B and C. However, many flavonoids can also lose one or two hydroxyl groups in ring A, a process related to the action of chalcone reductase and chalcone synthase enzymes. The enzymatic complex involved in the biosynthesis of the different classes of flavonoids is broad and with high specificity, through this complex, the alterations of the oxygenation patterns in the aryl moiety are realized. In addition, methylation, glycosylation, and dimethylation processes are responsible for increasing the possibilities of formation of different compounds, increasing the diversity of flavonoids distributed in different plant species (Dewick 2009).

Flavanones, the first group of flavonoids synthesized from chalcones, are the precursors of the other groups of flavonoids. Flavones are synthesized from reactions in the presence of flavone synthase I, oxygen and 2-oxo-glutarate and flavone synthase IIe, oxygen and NADPH. In the presence of oxygen, 2-oxoglutarate, and flavanone 3-hydroxylase enzyme, dihydroflavonols are produced, which are the precursors of flavonols and flavandiols. Finally, flavodiols act as precursors of the catechins and anthocyanidins, through specific enzymatic processes that occur in the presence of oxygen and NADPH, and by water elimination (Davies and Schwinn 2006; Dewick 2009). Figure 11.4 briefly illustrates the biosynthesis of flavonoids.

3 Flavonoid Composition

As described above, the main composition of *Baccharis* are flavonoids, diterpenes, and other phenolic compounds. From the *Baccharis* genus, which is composed of 441 species, only approximately 20% have been investigated in chemical aspects. The occurrence of flavonoids was reported in 86 distinct species of *Baccharis*; these studies lead to the identification of 129 flavonoids separated into 16 flavanones (Table 11.1), 11 flavanonols (Table 11.2), 46 flavones (Table 11.3), and 55 flavonols (Table 11.4).

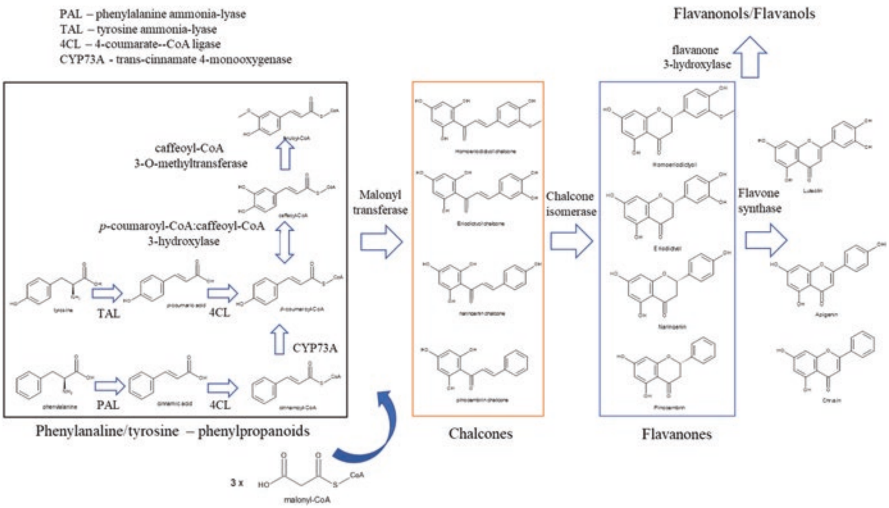


Fig. 11.4 Scheme of flavonoid biosynthesis

4 Flavanones

The main precursor of all flavonoids, naringenin (**1**), was found in aerial parts of *B. alaternoides* (Bohlmann et al. 1979), *B. conferta* (Weimann et al. 2002), *B. ligustrina* (Moreira et al. 2003a, b; Abad and Bermejo 2007), *B. polycephala* (Davila et al. 2013), *B. retusa* (Grecco et al. 2012a, b; Campos et al. 2016), *B. salzmannii* (Bohlmann et al. 1981a, b), and *B. varians* (Bohlmann et al. 1981a). Compound **1** was also found in the flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016), leaves of *B. dracunculifolia* (Fukuda et al. 2006; Campos et al. 2016) and *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007). The methylation of position C-7 leads to sakuranetin (**2**) accumulated in the aerial parts of *B. concinna* (Wollenweber et al. 2006), *B. marginalis* (Faine et al. 1987), *B. retusa* (Herz et al. 1977; Grecco et al. 2012a, b, 2014a, b; Rodriguez et al. 2012; Taguchi et al. 2015a, b; Sakoda et al. 2016; Bittencourt-Mernak et al. 2017; Ueno et al. 2018), *B. salicifolia* (del Corral et al. 2012; Campos et al. 2016), *B. serrulata* (Bohlmann et al. 1981a), and *B. trinervis* var. *rhexioides* (Bohlmann et al. 1979). This compound was also found in the roots of *B. leptocephala* (Bohlmann et al. 1981a) and *B. intermixta* (Bohlmann et al. 1981a) and leaves of *B. teindalensis*. The methylation at position C-4′ rather than C-7 of naringenin (**1**) affords isosakuranetin (**3**) identified in aerial parts of *B. alaternoides* (Bohlmann et al. 1979), *B. conferta* (Weimann et al. 2002), *B. dracuncunfolia*, within its roots and vegetative gems (da Silva Filho et al. 2004, 2008; Park et al. 2004; de Alencar et al. 2005; Lemos et al. 2007; Missima et al. 2007; de Sousa et al. 2009; Guimaraes et al. 2012; Figueiredo-Rinhel et al. 2013; Campos et al. 2016) and in *B. polycephala* (Davila et al. 2013), in the roots of *B. leptocephala* (Bohlmann et al. 1981b), and in the

Table 11.1 Flavanones identified in parts of species from genus *Baccharis*

	Compounds	Species	Parts	References
1	Naringenin	*B. alaternoides*	Above ground	Bohlmann et al. (1979)
		B. conferta	Aerial parts	Weimann et al. (2002)
		B. ligustrina	Aerial parts	Moreira et al. (2003a, b) and Abad and Bermejo (2007)
		B. polycephala	Aerial parts	Davila et al. (2013)
		B. retusa	Aerial parts	Campos et al. (2016) and Grecco et al. (2012a)
		B. salzmannii	Aerial parts	Bohlmann et al. (1981a) and Campos et al. (2016)
		B. varians	Aerial parts	Bohlmann et al. (1981a)
		B. illinita	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
		B. dracunculifolia	Leaves	Fukuda et al. (2006) and Campos et al. (2016)
		B. pseudotenuifolia	Leaves, shrub	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. (2016)
2	Sakuranetin	*B. concinna*	Aerial (leaves and stems)	Wollenweber et al. (2006)
		B. marginalis	Aerial parts	Faine et al. (1987)
		B. retusa	Aerial parts	Herz et al. (1977), Grecco et al. (2012b, 2014a, b), Toledo et al. (2013), Taguchi et al. (2015a, b), Sakoda et al. (2016), Bittencourt-Mernak et al. (2017) and Ueno et al. (2018)
		B. salicifolia	Aerial parts	Campos et al. (2016) and del Corral et al. (2012)
		B. serrulata	Aerial parts	Bohlmann et al. (1981a)
		B. trinervis var. *rhexioides*	Above ground	Bohlmann et al. (1979)
		B. leptocephala	Roots	Bohlmann et al. (1981b)
		B. intermixta	Roots	Bohlmann et al. (1981a)
		B. teindalensis	Leaves	Vidari et al. (2003)
3	Isosakuranetin	*B. alaternoides*	Above ground	Bohlmann et al. (1979)
		B. conferta	Aerial parts	Weimann et al. (2002)
		B. dracunculifolia	Aerial, leaves, roots, and vegetative gems	da Silva Filho et al. (2004, 2008), Park et al. (2004), de Alencar et al. (2005), Lemos et al. (2007), Missima et al. (2007), de Sousa et al. (2009), Guimaraes et al. (2012), Figueiredo-Rinhel et al. (2013) and Campos et al. (2016)

(continued)

Table 11.1 (continued)

	Compounds	Species	Parts	References
		B. polycephala	Aerial parts	Davila et al. (2013)
		B. leptocephala	Roots	Bohlmann et al. (1981b)
		B. leptophylla	Shrub	Almanza et al. (2000) and Mollinedo et al. (2001)
4	5,6,7-trihydroxy-4′-methoxyflavanone	*B. conferta*	Aerial parts	Weimann et al. (2002)
		B. retusa	Aerial parts	Grecco et al. (2010a, b)
		B. teindalensis	Leaves	Vidari et al. (2003)
		B. viminea		Wollenweber et al. (1997)
5	5-hydroxy-4′,7-dimethoxyflavanone	*B. conferta*	Aerial parts	Weimann et al. (2002)
		B. polycephala	Aerial parts	Davila et al. (2013)
6	4′-hydroxy-5,7-dimethoxyflavanone	*B. alaternoides*	Above ground	Bohlmann et al. (1979)
7	Pinocembrin	*B. concinna*	Roots	Bohlmann et al. (1981b)
		B. oxyodonta	Roots	Bohlmann et al. (1981b) and Abad Martinez et al. (2005)
		B. viminea		Wollenweber et al. (1997)
8	5,7-dihydroxy-3′-methoxyflavanone	*B. truncata*	Roots	Bohlmann et al. (1981b)
9	Dihydrooroxylin A	*B. uncinella*	Aerial parts	Campos et al. (2016)
10	Eriodictyol	*B. concinna*	Aerial parts	Wollenweber et al. (2006)
		B. confertifolia	Aerial parts	Wollenweber et al. (2006)
		B. marginalis	Aerial parts	Faine et al. (1987)
		B. retusa	Aerial parts	Campos et al. (2016) and Grecco et al. (2012a)
		B. pseudotenuifolia	Shrub, leaves	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. 2016)
11	Eriodictyol-7-methylether	*B. concinna*	Aerial parts	Wollenweber et al. (2006)
12	Homoeriodictyol	*B. calliprinos*	Aerial parts	Gianello et al. (1999)
13	Eriodictyol-3′,4′-dimethylether	*B. calliprinos*	Aerial parts	Gianello et al. (1999)
14	Eriodictyol 7,3′,4′-trimethyl ether	*B. confertifolia*	Aerial parts	Wollenweber et al. (2006)
15	Filifolin	*B. concinna*	Aerial parts	Wollenweber et al. (2006)
		B. boliviensis	Aerial parts	Campos et al. (2016)
16	8- methoxyeriodictyol	*B. concinna*	Aerial parts	Wollenweber et al. (2006)

Table 11.2 Flavanonols identified in parts of species from genus *Baccharis*

	Compounds	Species	Parts	References
17	Aromadendrin/ dihydrokaempferol	*B. dracunculifolia*	Leaves	Guimaraes et al. (2012)
		B. pseudotenuifolia	Shrub	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. (2016)
		B. illinita	Leaves and flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
		B. retusa	Aerial parts	Campos et al. (2016) and Grecco et al. (2012a)
18	Aromadendrin-7-methyl ether	*B. dracunculifolia*	Aerial (leaves and stems)	Campos et al. (2016)
		B. illinita	Aerial (leaves and stems)	Campos et al. (2016) and Pizzolatti et al. (2006)
19	Dihydrokaempferide	*B. conferta*	Aerial parts	Weimann et al. (2002)
		B. dracunculifolia	Leaves, roots, flowers, buds, and stems	Figueiredo-Rinhel et al. (2013), da Silva Filho et al. (2004, 2008), Missima et al. (2007), Lemos et al. (2007); de Sousa et al. (2009, 2011), Resende et al. (2007), Rezende et al. (2014), Cestari et al. (2011), Midorikawa et al. (2003) and Kumazawa et al. (2003)
		B. leptophylla		Almanza et al. (2000) and Mollinedo et al. (2001)
20	3-acetoxy-4′,5,7-trihydroxyflavanone	*B. varians*	Aerial parts	(Bohlmann et al. (1981a) and Abad Martinez et al. (2005)
21	3- acetoxy-4′,5-dihydroxy-7-methoxyflavanone	*B. dracunculifolia*	Leaves	Campos et al. (2016) and Fukuda et al. (2006)
22	Pinobanksin	*B. oxyodonta*	Roots	Bohlmann et al. (1981b) and Abad Martinez et al. (2005)
		B. dracunculifolia	Leaves and vegetative gems	Park et al. (2004) and de Alencar et al. (2005)
23	Pinobanksin-3-acetate	*B. dracunculifolia*	Leaf bud	Park et al. (2005)
		B. trinervis		Jakupovic et al. (1986)
24	Taxifolin	*B. illinita*	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
		B. retusa	Aerial parts	Campos et al. (2016) and Grecco et al. (2012a)
25	Taxifolin-4′-methyl ether	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
26	8-prenyltaxifolin	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
27	Taxifolin-3-acetate	*B. varians*	Aerial parts	Bohlmann et al. (1981a) and Abad Martinez et al. (2005)

Table 11.3 Flavones identified in parts of species from genus *Baccharis*

	Compounds	Species	Parts	References
28	Apigenin	*B. bigelovii*	Aerial parts	Arriaga-Giner et al. (1986)
		B. crispa	Aerial parts	Palacios et al. (1983)
		B. dentata	Aerial parts	Sartor et al. (2013) and Campos et al. (2016)
		B. gaudichaudiana	Aerial parts	Fullas et al. (1994), Guo et al. (2007), Visintini et al. (2013) and Campos et al. (2016)
		B. notosergila	Aerial parts	Palacios et al. (1983)
		B. pedicellata	Aerial parts	Faine et al. (1987)
		B. retusa	Aerial parts	Campos et al. (2016) and Grecco et al. (2012a)
		B. salicifolia	Aerial parts	Bohlmann et al. (1981b), Wollenweber et al. (1986) and Campos et al. (2016)
		B. salzmannii	Aerial parts	Campos et al. (2016)
		B. trimera	Aerial parts and epigeous parts	Soicke and Leng-Eschlow (1987), Nakasugi and Komai (1998) and Nakasugi (1990)
		B. illinita	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
		B. pseudotenuifolia	Leaves and shrub	Moreira et al. (2003a, b), Abad and Bermejo (2007) andCampos et al. (2016)
		B. teindalensis	Leaves	Vidari et al. (2003)
		B. dracunculifolia	Vegetative gems	de Alencar et al. (2005)
		B. genistelloides		Kuroyanagi et al. (1985), Abad Martinez et al. (2005) and Hennig et al. (2011)
		B. heterophylla		Wollenweber et al. (1986)
		B. pteronioides		Wollenweber et al. (1986)
		B. ramosissima		(Bohlmann et al. 1981b)
		B. tola		San Martin et al. (1982, 1983) and Abad Martinez et al. (2005)

(continued)

Table 11.3 (continued)

	Compounds	Species	Parts	References
		B. trinervis		Arriaga et al. (1982)
		B. vaccinioides		Wollenweber et al. (1986)
		B. viminea		Wollenweber et al. (1997)
29	Isoscutellarein	*B. pilularis*		Wollenweber et al. (1997)
30	Acacetin	*B. articulata*	Aerial parts	Gianello and Giordano (1984) and Cariddi et al. (2012)
		B. conferta	Aerial parts	Weimann et al. (2002)
		B. polycephala	Aerial parts	Davila et al. (2013)
		B. dracunculifolia	Leaves	Park et al. (2004) and da Silva Filho et al. (2009)
		B. rhomboidalis	Leaves	Silva et al. (1971)
		B. grandicapitulata		Bohlmann et al. (1985)
		B. patagonica		Zdero et al. (1986) and Rivera et al. (1988)
		B. salicifolia		Wollenweber et al. (1986)
		B. trinervis		Arriaga et al. (1982)
		B. vaccinioides		Wollenweber et al. (1986)
		B. viminea		Wollenweber et al. (1997)
31	Genkwanin	*B. crispa*	Aerial parts	Palacios et al. (1983)
		B. notosergila	Aerial parts	Palacios et al. (1983)
		B. pedicellata	Aerial parts	Faine et al. (1987)
		B. trimera	Aerial parts	Soicke and Leng-Eschlow (1987) and Nakasugi and Komai (1998)
		B. trinervis	Leaves	Herrera et al. (1996)
		B. genistelloides		Abad Martinez et al. (2005) and Hennig et al. (2011)
		B. pilularis var. *consanguinea*		Wollenweber et al. (1997)
32	Thevetiaflavone	*B. gaudichaudiana*	Aerial parts	Guo et al. (2007) and Campos et al. (2016)
33	7-hydroxy-5,4′-dimethoxyflavone	*B. articulata*		de Oliveira et al. (2014)
		B. usterii	Aerial parts	de Oliveira et al. (2014)

(continued)

Table 11.3 (continued)

	Compounds	Species	Parts	References
34	5-hydroxy-4′,7-dimethoxyflavone	*B. conferta*	Aerial parts	Weimann et al. (2002)
		B. crispa	Aerial parts	Bandoni et al. (1978)
		B. illinita	Aerial parts	Arriaga-Giner et al. (1986) and Campos et al. (2016)
		B. rhomboidalis	Leaves	Silva et al. (1971)
		B. teindalensis	Leaves	Vidari et al. (2003)
		B. tola	Leaves	San Martin et al. (1982)
		B. trinervis	Leaves	Herrera et al. (1996)
		B. latifolia		Salcedo et al. (2001)
35	Chrysin	*B. dracunculifolia*	Leaves	Paula et al. (2017) and Park et al. (2004)
		B. viminea		Wollenweber et al. (1997)
36	7-methylchrysin	*B. viminea*		Wollenweber et al. (1997)
37	2′-methoxychrysin	*B. illinita*	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
38	Hispidulin	*B. flabellata*	Aerial parts	Saad et al. (1988)
		B. gaudichaudiana	Aerial parts	Campos et al. (2016), Fullas et al. (1994) and Akaike et al. (2003)
		B. genistelloides	Aerial parts	Daily et al. (1984) and San Martin et al. (2012)
		B. grisebachii	Aerial parts	Abad and Bermejo (2007) and Tapia et al. (2004)
		B. halimifolia	Aerial parts	Joshi et al. (1997) and Jakupovic et al. (1990)
		B. ligustrina	Aerial parts	Abad and Bermejo (2007), Moreira et al. (2003a, b) and Nogueira et al. (2016)
		B. magellanica	Aerial parts	Cordano et al. (1982)
		B. rhomboidalis	Aerial parts	Cordano et al. (1982)
		B. trimera	Aerial and epigeous	Nakasugi and Komai (1998), Soicke and Leng-Eschlow (1987), Nakasugi (1990) and Padua et al. 2014)
		B. uncinella	Aerial parts	Campos et al. (2016) and Grecco et al. (2010a, b, 2014a, b)

(continued)

Table 11.3 (continued)

	Compounds	Species	Parts	References
		B. pseudotenuifolia	Leaves and shrub	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. (2016)
		B. vaccinioides		Wollenweber et al. (1986)
39	Pectolinaringenin	*B. concava*	Aerial parts	Zamorano et al. (1987)
		B. conferta	Aerial parts	Weimann et al. (2002)
		B. decussata	Aerial parts	Morales Mendez et al. (1984) and Rojas and Morales (2000)
		B. grisebachii	Aerial parts	Gianello and Giordano (1987), Abad Martinez et al. (2005) and Feresin et al. (2003)
		B. uncinella	Aerial parts	Grecco et al. (2010a, b, 2014a, b), Passero et al. (2011), Zalewski et al. (2011) and Campos et al. (2016)
		B. pedunculata	Leaf	Rahalison et al. (1995)
		B. trinervis	Branches	Sharp et al. (2000) and Abad Martinez et al. (2005)
		B. macraei	Fresh	Faini et al. (1991)
		B. pilularis var. consanguinea		Wollenweber et al. (1997)
		B. vaccinioides		Wollenweber et al. (1986)
40	Cirsimaritin	*B. concava*	Aerial parts	Zamorano et al. (1987)
		B. concinna	Aerial parts	Wollenweber et al. (2006)
		B. conferta	Aerial parts	Weimann et al. (2002)
		B. genistelloides	Aerial parts	Suttisri et al. (1994), Abad Martinez et al. (2005) and Hennig et al. (2011)
		B. rhomboidalis	Aerial parts	Labbe et al. (1986)
		B. rufescens var. *rufescens.*	Aerial parts	Simirgiotis et al. (2003), Abad and Bermejo (2007) and Campos et al. (2016)
		B. trimera	Aerial parts	Nakasugi (1990) and Nakasugi and Komai (1998)

(continued)

Table 11.3 (continued)

	Compounds	Species	Parts	References
		B. elaeagnoides		Mesquita et al. (1985)
		B. halimifolia		Joshi et al. (1997)
		B. intermedia		Faini et al. (1991)
		B. macraei		Faini et al. (1991)
		B. pilularis var. *consanguinea*		Wollenweber et al. (1997)
		B. tricuneata		Wagner et al. (1978)
41	Scutellarein-7,4′-dimethyl ether	*B. tucumanensis*	Aerial parts	Tonn et al. (1982)
42	Salvigenin	*B. concava*	Aerial parts	Zamorano et al. (1987)
		B. conferta	Aerial parts	Weimann et al. (2002)
		B. rhomboidalis	Aerial parts	Labbe et al. (1986)
		B. scandens	Aerial parts	Cabrera et al. (2016)
		B. trinervis	Branches	Sharp et al. (2000) and Abad Martinez et al. (2005)
		B. macraei		Faini et al. (1991)
		B. pilularis		Wollenweber et al. (1997)
43	Desmethoxysudachitin	*B. grisebachii*	Aerial parts	Gianello and Giordano (1987), Tapia et al. (2004), Abad Martinez et al. (2005) and Campos et al. (2016)
		B. solierii	Aerial parts	Labbe et al. (1986)
44	Nevadensin	*B. decussata*	Aerial parts	Rojas and Morales (2000)
		B. grisebachii	Aerial parts	Gianello and Giordano (1987), Feresin et al. (2003), Tapia et al. (2004) and Abad Martinez et al. (2005)
		B. nitida	Aerial parts	Chidiak et al. (2007) and Campos et al. (2016)
45	Xantomicrol	*B. boliviensis*	Aerial parts	Calle et al. (2012) and Campos et al. (2016)
		B. nitida	Aerial parts	Chidiak et al. (2007) and Campos et al. (2016)
		B. patens	Aerial parts	Silva et al. (1985)
		B. scandens	Aerial parts	Cabrera et al. (2016)
		B. tucumanensis	Aerial parts	Tonn et al. (1982)
		B. pentlandii	Leaves	Tarqui et al. (2012)
		B. quitensis	Roots	Bohlmann et al. (1981b)
46	Gardenin B	*B. grisebachii*	Aerial parts	Feresin et al. (2003), Tapia et al. (2004) and Campos et al. (2016)

(continued)

Table 11.3 (continued)

	Compounds	Species	Parts	References
		B. scandens	Aerial parts	Cabrera et al. (2016)
47	Tangeretin	*B. illinita*	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
48	Luteolin	*B. articulata*	Aerial parts	Cariddi et al. (2012)
		B. bigelovii	Aerial parts	Arriaga-Giner et al. (1986) and Wollenweber et al. (1986)
		B. concinna	Aerial parts	Wollenweber et al. (2006)
		B. confertifolia	Aerial parts	Wollenweber et al. (2006)
		B. gaudichaudiana	Aerial parts	Guo et al. (2007)
		B. genistelloides	Aerial parts	San Martin et al. (2012)
		B. incarum	Aerial parts	Zampini et al. (2009) and Campos et al. (2016)
		B. linearis	Aerial parts	Wollenweber et al. (2006)
		B. lycioides	Aerial parts	Wollenweber et al. (2006)
		B. reticularia	Aerial parts	Bohlmann et al. (1981a)
		B. trimera	Aerial parts	Soicke and Leng-Eschlow (1987), da Silva et al. (2016) and Menezes et al. (2016)
		B. trinervis	Aerial parts	Jaramillo-Garcia et al. (2018)
		B. varians	Aerial parts	Bohlmann et al. (1981a)
		B. illinita	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
		B. halimifolia		Wollenweber et al. (1997)
		B. microcephala		Bohlmann et al. (1985)
		B. nitida		Bohlmann et al. (1985)
		B. pteronioides		Wollenweber et al. (1986)
49	Chrysoeriol	*B. salicifolia*	Aerial parts	Warning et al. (1986)
		B. pseudotenuifolia	Leaves and shrub	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. (2016)

(continued)

Table 11.3 (continued)

	Compounds	Species	Parts	References
		B. illinita	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
50	Luteolin-4′,7-dimethylether	*B. trimera*	Aerial parts	Padua et al. (2014) and de Araujo et al. (2016)
		B. trinervis	Leaves	Herrera et al. (1996)
51	Luteolin-3′,7-dimethylether	*B. calliprinos*	Aerial parts	Gianello et al. (1999)
		B. rhetinodes	Aerial parts	Gianello et al. (1999)
		B. salicifolia	Aerial parts	Warning et al. (1986)
52	5-hydroxy-7,3′,4′-trimethoxyflavone, luteolin-3′,4′,7-trimethylether	*B. crispa*	Aerial parts	Bandoni et al. (1978)
		B. latifolia	Aerial parts	Salcedo et al. (2003) and Campos et al. (2016)
		B. trinervis	Leaves	Rivera et al. (1988)
53	6-hydroxyluteolin	*B. boliviensis*	Aerial parts	Abad and Bermejo (2007)
54	Nepetin; eupafolin	*B. concinna*	Aerial parts	Verdi et al. (2004)
		B. confertifolia	Aerial parts	Verdi et al. (2004)
		B. flabellata	Aerial parts	Bandoni et al. (1978)
		B. gaudichaudiana	Aerial parts	Salcedo Ortiz et al. (2001) and Abad and Bermejo (2007)
		B. genistelloides	Aerial parts	San Martin et al. (2012)
		B. linearis	Aerial parts	He (1995), He et al. (1996) and Wollenweber et al. (2006)
		B. lycioides	Aerial parts	Wollenweber et al. (2006)
		B. trimera	Aerial parts	Soicke and Leng-Eschlow (1987) and Simões-Pires et al. (2005)
55	Jaceosidin	*B. concinna*	Aerial parts	Wollenweber et al. (2006)
		B. flabellata	Aerial parts	Saad et al. (1988)
		B. gaudichaudiana	Aerial parts	Akaike et al. (2003) and Campos et al. (2016)
		B. grisebachii	Aerial parts	Tapia et al. (2004)
56	Desmethoxycentaureidin	*B. gaudichaudiana*	Aerial parts	Akaike et al. (2003) and Campos et al. 2016)
		B. solierii	Stems and leaves	Labbe et al. (1986)
		B. petiolata		Labbé et al. (1990)
		B. salicina		Parodi and Fischer (1988) and Quijano et al. (1998)

(continued)

Table 11.3 (continued)

	Compounds	Species	Parts	References
57	Cirsiliol	*B. concinna*	Leaves and stems	Wollenweber et al. (2006)
		B. confertifolia	Leaves and stems	Wollenweber et al. (2006)
		B. flabellata	Aerial parts	Saad et al. (1988)
		B. linearis	Leaves and stems	Wollenweber et al. (2006)
		B. rufescens var. *rufescens* .	Aerial parts	Simirgiotis et al. (2003), Abad and Bermejo (2007) and Campos et al. (2016)
		B. genistelloides		Kuroyanagi et al. (1985), Abad Martinez et al. (2005) and Hennig et al. (2011)
		B. tricuneata		Wagner et al. (1978)
58	Cirsilineol	*B. concinna*	Aerial parts	Wollenweber et al. (2006)
		B. salicifolia	Aerial parts	Warning et al. (1986)
		B. genistelloides		Abad Martinez et al. (2005) and Hennig et al. (2011)
59	5,6-Dihydroxy-3′,4′,7-trimethoxyflavone	*B. trimera*	All plants	Borella et al. (2006)
60	Eupatilin	*B. conferta*	Aerial parts	Weimann et al. (2002)
		B. gaudichaudiana	Aerial parts	Akaike et al. (2003) and Campos et al. 2016)
61	Eupatorin	*B. genistelloides*	Aerial parts	Suttisri et al. (1994) and Hennig et al. (2011)
		B. trimera	Leaves, stems, flowers, and fruits	Herz et al. (1977), de Mello and Petrovick (2000), Torres et al. (2000), da Silva et al. (2004), Silva et al. (2006), Padua et al. (2014) and de Araujo et al. (2016)
62	5-hydroxy-3′,4′,6,7-tetramethoxyflavone	*B. genistelloides*	Aerial parts	Suttisri et al. (1994)
		B. trimera	Leaves	Rendon and Vila (1995) and Silva et al. (2006)
63	Sideritiflavone	*B. patens*	Aerial parts	Silva et al. (1985)
		B. thymifolia	Aerial parts	Saad et al. (1987)
		B. pentlandii	Leaves	Tarqui et al. (2012) and Campos et al. (2016)

(continued)

Table 11.3 (continued)

	Compounds	Species	Parts	References
64	4′,5-dihydroxy-3′,6,7,8-tetramethoxyflavone, 7-methylsudachitin, 3′-methoxyxanthomicrol	*B. incarum*	Aerial parts	Faini et al. (1982a, b)
		B. salicifolia	Aerial parts	Warning et al. (1986)
		B. thymifolia	Aerial parts	Saad et al. (1987)
		B. pentlandii	Leaves	Tarqui et al. (2012) and Campos et al. (2016)
		B. oxyodonta	Roots	Bohlmann et al. (1981b)
		B. quitensis	Roots	Bohlmann et al. (1981b)
65	Gardenin D	*B. patens*	Aerial parts	Silva et al. (1985)
66	5-Hydroxy-3′,4′,6,7,8-pentamethoxytlavone	*B. thymifolia*	Aerial parts	Saad et al. (1987)
67	Nobiletin	*B. illinita*	Flowers	Abad and Bermejo (2007) and Campos et al. (2016)
68	Isoschaftoside	*B. gaudichaudiana*	Aerial parts	Akaike et al. (2003 and Campos et al. (2016)
69	Vicenin II	*B. trimera*	Aerial parts	Rabelo et al. (2017)
		B. trimera	Aerial parts	Rabelo et al. (2017)
70	6(8)-C-furanosyl-8(6)-C-hexosyl flavone	*B. trimera*	Aerial parts	de Araujo et al. (2016)
71	6(8)-C- hexosyl-8(6)-C-furanosyl flavone	*B. trimera*	Aerial parts	de Araujo et al. (2016) and Rabelo et al. (2017)
72	5,3′-dihydroxy-4′-methoxy-7-O-pyranosyl-furanosyl flavone	*B. trimera*	Aerial parts	Padua et al. (2014)

shrub *B. leptophylla*. The C-6 hydroxylation of isosakuranetin (**3**) leads to the formation of 5,6,7-trihydroxy-4′-methoxyflavanone (**4**) accumulated in the leaves and aerial parts of *B. conferta* (Weimann et al. 2002), *B. retusa* (Grecco et al. 2010a, b), *B. teindalensis* (Vidari et al. 2003), and *B. viminea* (Wollenweber et al. 1997). The dimethoxy derivative of naringenin (**1**), 5-hydroxy-4′,7-dimethoxyflavanone (**5**), was identified in the aerial parts of *B. conferta* (Weimann et al. 2002) and *B. polycephala* (Davila et al. 2013) and 4′-hydroxy-5,7-dimethoxyflavanone (**6**) in ground parts of *B. alaternoides* (Bohlmann et al. 1979). The 4′-dehydroxylated derivative, pinocembrin (**7**), was identified in *B. viminea* (Wollenweber et al. 1997), in the roots of *B. concinna* (Bohlmann et al. 1981b), and in *B. oxyodonta* (Bohlmann et al. 1981b; Abad Martinez et al. 2005). Less frequently isolated 3’- and 6-monomethoxylated derivatives of pinocembrin (**7**): 5,7-dihydroxy-3′-methoxyflavanone (**8**) and 5,7-dihydroxy-6-methoxyflavanone, known as dihydrooroxylin A (**9**), were identified in the roots of *B. truncata* [27] and aerial parts of *B. uncinella*, respectively (Grecco et al. 2010a, b; Campos et al. 2016).

Table 11.4 Flavanols identified in parts of species from genus *Baccharis*

	Compounds	Species	Parts	References
73	Kaempferol	*B. conferta*	Aerial parts	Weimann et al. (2002)
		B. dentata	Aerial parts	Sartor et al. (2013) and Campos et al. (2016)
		B. gaudichaudiana	Aerial parts	Campos et al. (2016)
		B. polycephala	Aerial parts	Davila et al. (2013)
		B. retusa	Aerial parts	Grecco et al. (2012a) and Campos et al. (2016)
		B. illinita	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
		B. maritima	Flowering tops	Moreira et al. (1975)
		B. pseudotenuifolia	Shrub, leaves	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. (2016)
		B. trimera	Leaves	da Silva et al. (2016)
		B. dracunculifolia	Leaves, buds, stems and vegetative gems	Midorikawa et al. (2003), Park et al. (2004, 2005) and de Alencar et al. (2005)
		B. genistelloides		Daily et al. (1984)
		B. pilularis var. consanguinea		Wollenweber et al. (1997)
74	Isokaempferide	*B. linearis*	Aerial parts	Wollenweber et al. (2006) and Faini et al. (1999)
		B. lycioides	Aerial parts	Wollenweber et al. (2006)
		B. pedicellata	Aerial parts	Faine et al. (1987)

(continued)

Table 11.4 (continued)

	Compounds	Species	Parts	References
		B. papillosa	Leaves	Campos et al. (2016) and Escobar et al. (2009)
		B. intermedia		Faini et al. (1991)
		B. linearis		Faini et al. (1991)
		B. macraei		Faini et al. (1991)
		B. pilularis var. *consanguinea*		Wollenweber et al. (1997)
75	Kaempferide	*B. conferta*	Aerial parts	Weimann et al. (2002)
		B. polycephala	Aerial parts	Davila et al. (2013)
		B. dracunculifolia	Flowers, leaves, buds, stems and vegetative gems	Midorikawa et al. (2003), Park et al. (2004, 2005), de Alencar et al. (2005), Piantino et al. (2008), Campos et al. (2016) and Paula et al. (2017)
		B. leptophylla		Almanza et al. (2000) and Mollinedo et al. (2001)
		B. pilularis var. consanguinea		Wollenweber et al. (1997)
		B. viminea		Wollenweber et al. (1997)
76	Kaempferol-7-methyleter	*B. pilularis var. consanguinea*		Wollenweber et al. (1997)
77	Ermanin	*B. papillosa*	Leaves	Campos et al. (2016)
		B. dracunculifolia	Buds; leaves; stems	Midorikawa et al. (2003) and da Silva Filho et al. (2009)
		B. pilularis var. consanguinea		Wollenweber et al. (1997)
		B. viminea		Wollenweber et al. (1997)
78	Kaempferol-7,4′-dimethyl ether	*B. crispa*	Aerial parts	Bandoni et al. (1978)

(continued)

Table 11.4 (continued)

	Compounds	Species	Parts	References
		B. Illinita	Leaves and stems	Campos et al. (2016) and Pizzolatti et al. (2006)
		B. teindalensis	Leaves	Vidari et al. (2003)
79	Kaempferol-3,7-dimethylether	*B. pedicellata*	Aerial parts	Faine et al. (1987)
		B. santelicis	Aerial parts	Zdero et al. (1991)
		B. pilularis var. consanguinea		Wollenweber et al. (1997)
80	Kaempferol-3,4′,7-trimethylether	*B. illinita*	Aerial parts	Campos et al. (2016) and Pizzolatti et al. (2006)
		B. santelicis	Aerial parts	Zdero et al. (1991)
81	Galangin	*B. dracunculifolia*	Leaf bud	Park et al. (2005)
		B. viminea		Wollenweber et al. (1997)
82	Galangin-7-methylether	*B. viminea*		Wollenweber et al. (1997)
83	6-hydroxykaempferol	*B. pilularis var. consanguinea*		Wollenweber et al. (1997)
84	6-methoxykaempferol	*B. dracunculifolia*	Leaves	Kumazawa et al. (2003)
85	4′,6-dimethoxykaempferol	*B. conferta*	Aerial parts	Weimann et al. (2002)
86	6,7-dimethoxykaempferol	*B. pilularis var. consanguinea*		Wollenweber et al. (1997)
87	Penduletin	*B. pedunculata*	Leaves	Rahalison et al. (1995)
		B. trinervis	Branches	Sharp et al. (2000 and Abad Martinez et al. (2005)
		B. salicifolia		Wollenweber et al. (1986)
		B. sarothroides		Wollenweber et al. (1986)
		B. vaccinioides		Wollenweber et al. (1986)
88	Herbacetin-3-methyl ether	*B. pilularis var. consanguinea*		Wollenweber et al. (1997)
89	Quercetin	*B. articulata*	Aerial parts	Campos et al. (2016)

(continued)

Table 11.4 (continued)

	Compounds	Species	Parts	References
		B. bigelovii	Aerial parts	Wollenweber et al. (1986) and Grecco et al. (2014a, b)
		B. concinna	Aerial parts	Wollenweber et al. (2006)
		B. confertifolia	Aerial parts	Wollenweber et al. (2006)
		B. dentata	Aerial parts	Sartor et al. (2013) and Campos et al. (2016)
		B. genistelloides	Aerial parts	Montes et al. (1971) and Morales Mendez et al. (1984)
		B. grisebachii	Aerial parts	Moreira et al. (1975)
		B. linearis	Aerial parts	Wollenweber et al. (2006)
		B. lycioides	Aerial parts	Wollenweber et al. (2006)
		B. pteronioides	Aerial parts	Wollenweber et al. (1986) and Jakupovic et al. (1990)
		B. retusa	Aerial parts	Grecco et al. (2012a), Ferreira et al. (2015) and Campos et al. (2016)
		B. salicifolia	Aerial parts	Wollenweber et al. (1986)
		B. scandens	Aerial parts	Cabrera et al. (2016)
		B. thesioides	Aerial parts	Liu et al. (1993)
		B. trimera	Aerial parts	Soicke and Leng-Eschlow (1987), Simões-Pires et al. (2005), Padua et al. (2014), da Silva et al. (2016), de Araujo et al. (2016), Menezes et al. (2016) and Sabir et al. (2017)

(continued)

Table 11.4 (continued)

	Compounds	Species	Parts	References
		B. trinervis	Aerial parts	Jaramillo-Garcia et al. (2018)
		B. dracunculifolia	Leaf bud and flowers	Midorikawa et al. (2003) and Park et al. (2005)
		B. pseudotenuifolia	Leaves and shrubs	
		B. spicata	Leaves, stems, and flowers	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. (2016)
		B. Illinita	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
		B. maritima	Flowering tops	Moreira et al. (1975)
		B. viminea		Wollenweber et al. (1997)
90	Rhamnetin	*B. confertifolia*	Leaves and stems	Wollenweber et al. (2006)
		B. pilularis var. consanguinea		Wollenweber et al. (1997)
91	Isorhamnetin	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
		B. linearis	Leaves and stems	Wollenweber et al. (2006) and He (1995)
		B. lycioides	Leaves and stems	Wollenweber et al. (2006)
		B. pseudotenuifolia	Leaves and shrub	
		B. viminea		Wollenweber et al. (1997)
92	3-methylquercetin	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
		B. trimera	Aerial parts	de Mello and Petrovick (2000)
		B. linearis	Leaves	Faini et al. (1999)
		B. papillosa	Leaves	Campos et al. (2016)

(continued)

Table 11.4 (continued)

	Compounds	Species	Parts	References
		B. illinita	Flowers	Verdi et al. (2004), Abad and Bermejo (2007) and Campos et al. (2016)
		B. halimifolia		Wollenweber et al. (1997)
		B. intermedia		Faini et al. (1991)
		B. linearis		Faini et al. (1991)
93	Rhamnazin	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
		B. confertifolia	Leaves and stems	Wollenweber et al. (2006)
		B. latifolia		Salcedo Ortiz et al. (2001)
94	Isorhamnetin 3-methyl ether	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
		B. linearis	Leaves and stems	Wollenweber et al. (2006) and Faini et al. (1999)
		B. lycioides	Leaves and stems	Wollenweber et al. (2006)
		B. intermedia		Faini et al. (1991)
		B. linearis		Faini et al. (1991)
95	3,4′-dimethoxy-3′,5,7-trihydroxyflavone	*B. sarothroides*		Abad Martinez et al. (2005)
96	3,7-dimethoxyquercetin	*B. triangularis*	Aerial parts	Gianello and Giordano (1989)
		B. pilularis var. consanguinea		Wollenweber et al. (1997)
97	3,7-dimethyl-isorhamnetin	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
98	3,7,4′-trimethylquercetin	*B. illinita*	Leaves and stems	Campos et al. (2016, 46)
		B. grisebachii		Abad and Bermejo (2007)
99	3,5-dihydroxy-7,3′,4′-trimethoxyflavone	*B. latifolia*		Salcedo Ortiz et al. (2001)
100	Retusin	*B. illinita*	Leaves and stems	Campos et al. (2016, 46)

(continued)

Table 11.4 (continued)

	Compounds	Species	Parts	References
101	3-hydroxy-5,7,3′,4’tetramethoxyflavone	*B. latifolia*	Aerial parts	Campos et al. (2016, 121)
		B. conferta	Aerial parts	Weimann et al. (2002)
102	Patuletin	*B. concinna*	Leaves and stems	Wollenweber et al. (2006)
		B. confertifolia	Leaves and stems	Wollenweber et al. (2006)
		B. halimifolia		Wollenweber et al. (1997)
		B. pilularis var. consanguinea		Wollenweber et al. (1997)
103	3′-methylpatuletin	*B. halimifolia*		Wollenweber et al. (1997)
104	Axillarin	*B. incarum*	Leaves and stems	Campos et al. (2016)
		B. linearis	Leaves and stems	Wollenweber et al. (2006) and Labbe et al. (1986)
		B. solierii	Leaves and stems	Labbe et al. (1986)
		B. halimifolia		Wollenweber et al. (1997)
105	Eupatolitin	*B. confertifolia*	Leaves and stems	Wollenweber et al. (2006)
		B. gaudichaudiana	Aerial parts	Akaike et al. (2003)
106	Centaureidin	*B. sarothroides*	Leaves and twigs	Abad Martinezet al. (2005) and Montes et al. (1971)
		B. solierii	Leaves and stems	Labbe et al. (1986)
		B. salicina		Parodi and Fischer (1988) and Quijano et al. (1998)
107	5,7-dihydroxy-3,6,3′,4′-tetramethoxyflavone	*B. salicina*		Quijano et al. (1998)
108	3,3′-dimethylgossypetin	*B. linearis*	Leaves and stems	Wollenweber et al. (2006)
109	3,8-dimethylgossypetin	*B. linearis*	Leaves and stems	Wollenweber et al. (2006)
110	3,8,3′-trimethylgossypetin	*B. linearis*	Leaves and stems	Wollenweber et al. (2006)

(continued)

Table 11.4 (continued)

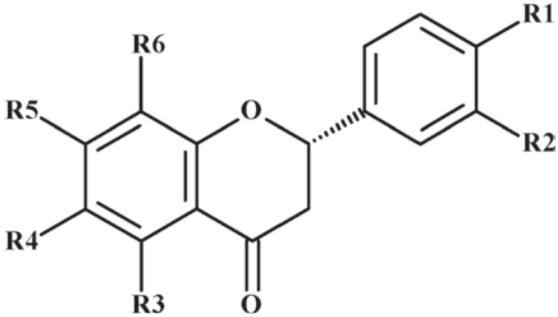
	Compounds	Species	Parts	References
111	3′,4′,5,7-tetrahydroxy-3,6,8-trimethoxyflavone	*B. incarum*	Leaves and stems	Campos et al. (2016)
112	4′,5,7-trihydroxy-3,3′,6,8-tetramethoxyflavone	*B. incarum*	Leaves and stems	Campos et al. (2016)
		B. solierii	Leaves and stems	Labbe et al. (1986)
113	3′,5-dihydroxy-3,4′,6,7,8-pentamethoxyflavone	*B. boliviensis*	Aerial parts	Campos et al. (2016)
114	4′,5-dihydroxy3′,3,6,7,8-pentamethoxyflavone	*B. incarum*	Leaves and stems	Faini et al. (1982a, b), Nuño et al. (2012) and Campos et al. (2016)
115	3-O-acetylmyricetin	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
116	Myricetin 7,3′-dimethylether	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
117	Myricetin 7,3′,5′-trimethylether	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
118	Myricetin 3′,5′,7,8-tetramethylether	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
119	6-hydroxy-7,3′,5′-trimethylmyricetin	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
120	6-hydroxy-3,7,3′,5′-tetramethylmyricetin	*B. tola*	Aerial parts	Simirgiotis et al. (2016)
121	Apigenin 3-O-β-D-glucopyranoside/ astragalin	*B. Dracunculifolia*	Aerial parts	Nagatani et al. (2001)
		B. angustifolia		Wagner et al. (1972)
122	Kaempferol-3-O-rutinoside/ nicotiflorin	*B. antioquensis*	Leaves	Mejia-Giraldo et al. (2016)
123	Quercetin 3-O-[β-D-apiofuranosyl (1 → 2)α-Lrhamnopyranosyl (1 → 6)]-β-D-glucopyranoside	*B. thesioides*	Aerial parts	Liu et al. (1993)
124	Isoquercetin	*B. dracunculifolia*	Aerial parts	Nagatani et al. (2001)
		B. thesioides	Aerial parts	Kakehashu et al. (2016)
		B. trimera	Aerial parts	Simões-Pires et al. (2005)
		B. pseudotenuifolia	Leaves and shrub	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. (2016)

(continued)

Table 11.4 (continued)

	Compounds	Species	Parts	References
		B. angustifolia		Wagner et al. (1972)
		B. ochracea		Schenkel et al. (1997)
125	Hyperoside	*B. dracunculifolia*	Aerial parts	Nagatani et al. (2001)
		B. thesioides	Aerial parts	Nagatani et al. (2001)
126	Quercitrin	*B. gaudichaudiana*	Aerial parts	Campos et al. (2016) and Akaike et al. (2003)
		B. microdonta	Leaves	Toyama et al. (2014)
		B. pseudotenuifolia	Leaves and shrubs	Moreira et al. (2003a, b), Abad and Bermejo (2007) and Campos et al. (2016)
127	Rutin	*B. gaudichaudiana*	Aerial parts	Campos et al. (2016) and Akaike et al. (2003)
		B. thesioides	Aerial parts	Tarqui et al. (2012)
		B. trinervis	Aerial parts	Jaramillo-Garcia et al. (2018)
		B. trimera	Aerial parts and leaves	Gene et al. (1996), Menezes et al. (2016) and Sabir et al. (2017)
		B. antioquensis	Leaves	Mejia-Giraldo et al. (2016)
		B. dentata	Leaves and stems	Campos et al. (2016) and Sartor et al. (2013)
		B. spicata	Leaves, stems, and flowers	Agudelo et al. (2016)
		B. genistelloides		Hennig et al. (2011)
128	Quercetin -3-O-(4″-O-caffeoyl)-rhamnopyranosyl-(1 → 6)-galactopyranoside – 174	*B. antioquensis*	Leaves	Mejia-Giraldo et al. (2016)

Eriodictyol (**10**) was found in aerial parts of *B. concinna* (Bohlmann et al. 1981b), *B. confertifolia* (Wollenweber et al. 2006), *B. marginalis* (Faine et al. 1987), *B. retusa* (Campos et al. 2016; Grecco et al. 2012a, b), and *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016). Six eriodictyol derivatives were found in *Baccharis* species: eriodictyol-7-methyl ether (**11**) at *B. concinna* (Wollenweber et al. 2006), homoeriodictyol (**12**) and eriodictyol-3′,4′-dimethyl ether (**13**) at *B. calliprinos* (Gianello et al. 1999), eriodictyol 7,3′,4′-trimethyl ether (**14**) at *B. confertifolia* (Wollenweber et al. 2006), filifolin (**15**) at *B. concinna* (Wollenweber et al. 2006) and *B. boliviensis* (Campos et al. 2016), and 8-methoxyeriodictyol (**16**) at *B. concinna* (Wollenweber et al. 2006). Flavanones identified at *Baccharis* species are summarized in Table 11.1, followed by their respective structures in Fig. 11.5.



1 – R1 = R3 = R5 = OH; R2 = R4 = R6 = H
2 - R1 = R3 = OH; R5 = OMe; R2 = R4 = R6 = H
3 – R1 = OMe; R3 = R5 = OH; R2 = R4 = R6 = H
4 – R1 = OMe; R3 = R4 = R5 = OH; R2 = R6 = H;
5 – R1 = R5 = OMe; R3 = OH; R2 = R4 = R6 = H
6 – R1 = OH; R3 = R5 = OMe; R2 = R4 = R6 = H
7 – R3 = R5 = OH; R1 = R2 = R4 = R6 = H
8 – R2 = OMe; R3 = R5 = OH; R1 = R4 = R6 = H
9 – R3 = R5 = OH; R4 = OMe; R1 = R2 = R6 = H
10 – R1 = R2 = R3 = R5 = OH; R4 = R6 = H
11 – R1 = R2 = R3 = OH; R5 = OMe; R4 = R6 = H
12 – R1 = R3 = R5 = OH; R2 = OMe; R4 = R6 = H
13 – R1 = R2 = OMe; R3 = R5 = OH; R4 = R6 = H
14 – R1 = R2 = R5 = OMe; R3 = OH; R4 = R6 = H
15 – R1 = R2 = R3 = R5 = OH; R4 = OMe; R6 = H
16 – R1 = R2 = R3 = R5 = OH; R6 = OMe; R4 = H

Fig. 11.5 Structures of flavanones **1**–**16** identified in *Baccharis* species

5 Flavanonols

The 3-hydroxylation of flavanones through 3-hydroxylase enzymes leads to the biosynthesis of flavanonol derivatives. Naringenin-3-hydroxylase affords aromadendrin, also known as dihydrokaempferol (**17**), identified in leaves of *B. dracunculifolia* (Guimaraes et al. 2012), shrubs of *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016), leaves and flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016), and in aerial parts of *B. retusa* (Campos et al. 2016; Grecco et al. 2012a). Aromadendrin-7-methyl ether (**18**) was isolated from aerial parts of *B. dracunculifolia* (Campos et al. 2016) and *B. illinita* (Pizzolatti et al. 2006). Dihydrokaempferide (**19**) was identified in the aerial parts of *B. conferta* (Weimann et al. 2002), in leaves, roots, flowers, buds, and stems of *B. dracunculifolia* (Figueiredo-Rinhel et al. 2013; da Silva Filho et al. 2004, 2008; Missima et al. 2007; Lemos et al. 2007; de Sousa et al. 2009, 2011; Resende et al. 2007; Rezende et al. 2014; Cestari et al. 2011Midorikawa et al. 2003; Kumazawa et al. 2003), and from *B. leptophylla* (Mollinedo et al. 2001; Almanza et al. 2000). 3-Acetylated derivative such as 3-acetoxy-4′ 5 7-trihydroxyflavanone (**20**) was isolated from aerial parts of *B. varians* (Bohlmann et al. 1981a; Abad Martinez et al. 2005), while 3-acetoxy-4′,5-dihydroxy-7-methoxyflavanone (**21**) was obtained from leaves of *B. dracunculifolia*, (Fukuda et al. 2006; Campos et al. 2016). A 4′-dehydroxylated derivative of aromadendrin, pinobanksin (**22**), was isolated from roots of *B. oxyodonta* (Bohlmann et al. 1981b; Abad Martinez et al. 2005) as well as from vegetative gems and leaves of *B. dracunculifolia* (Park et al. 2004; de Alencar et al. 2005). Additionally, its acetylated derivative, pinobanksin-3-acetate (**23**), was identified in *B. dracunculifolia* leaf bud (Park et al. 2005) and in *B. trinervis* (Jakupovic et al. 1986). Taxifolin (**24**) was identified in *B. illinita* (Abad and Bermejo 2007), especially in flowers (Verdi et al. 2004; Campos et al. 2016), as well as in aerial parts of *B. retusa* (Grecco et al. 2012a; Campos et al. 2016). 3-hydroxyhesperetin or taxifolin-4′-methyl ether (**25**), together with 8-prenyltaxifolin (**26**), were identified in aerial parts of *B. tola* (Simirgiotis et al. 2016). Furthermore, an acetylated derivative, taxifolin-3-acetate (**27**), was identified in aerial parts of *B. varians* (Bohlmann et al. 1981a; Abad Martinez et al. 2005). Flavanonols identified in *Baccharis* species are summarized in Table 11.2, followed by their respective structures in Fig. 11.6, Flavanonols identified in *Baccharis* species are summarized in Table 11.3, followed by their respective structures in Fig. 11.6.

6 Flavones

The enzymatic dehydration of flavanone naringenin (**1**) through flavone synthase affords apigenin (**28**) identified in the aerial parts of *B. bigelovii* (Arriaga-Giner et al. 1986), *B. crispa* (Palacios et al. 1983), *B. dentata* (Campos et al. 2016), *B. gaudichaudiana* (Fullas et al. 1994; Guo et al. 2007; Visintini et al. 2013; Campos

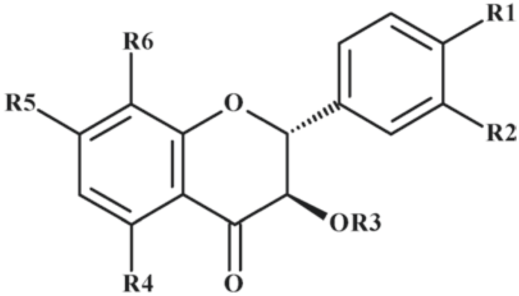


Fig. 11.6 Structures of flavanonols **17–27** identified in *Baccharis* species

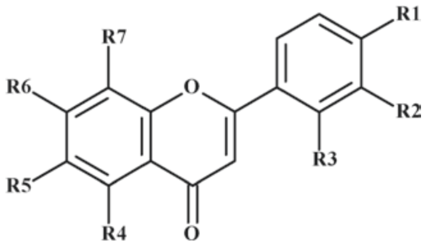
17 – R1 = R4 = R5 = OH; R2 = R3 = R6 = H
18 - R1 = R4 = OH; R5 = OMe; R2 = R3 = R6 = H
19 – R1 = OMe; R4 = R5 = OH; R2 = R3 = R6 = H
20 – R1 = R4 = R5 = OH; R3 = Acetyl; R2 = R6 = H
21 - R1 = R4 = OH; R3 = Acetyl; R5 = OMe; R2 = R6 = H
22 - R4 = R5 = OH; R1 = R2 = R3 = R6 = H
23 - R3 = Acetyl; R4 = R5 = OH; R1 = R2 = R6 = H
24 - R1 = R2 = R4 = R5 = OH; R3 = R6 = H
25 - R1 = OMe; R2 = R4 = R5 = OH; R3 = R6 = H
26 - R1 = R2 = R4 = R5 = OH; R6 = Prenyl; R3 = H
27 - R1 = R2 = R4 = R5 = OH; R3 = Acetyl; R6 = H

et al. 2016), *B. notosergila* (Palacios et al. 1983), *B. pedicellata* (Faine et al. 1987), *B. retusa* (Grecco et al. 2012a; Campos et al. 2016), *B. salicifolia* (Campos et al. 2016; Bohlmann et al. 1981b), *B. salzmannii* (Campos et al. 2016), as well as in the aerial and epigeous parts of *B. trimera* (Nakasugi 1990, 1998; Fullas et al. 1994). This compound was also identified in the flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016), leaves, and shrubs of *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016) and *B. teindalensis* (Vidari et al. 2003), and vegetative gems of *B. dracunculifolia* (de Alencar et al. 2005). The flavone **28** was also found in *B. genistelloides* (Kuroyanagi et al. 1985; Abad Martinez et al. 2005; Hennig et al. 2011), *B. heterophylla* (Wollenweber et al. 1986), *B. pteronioides* (Wollenweber et al. 1986), *B. ramosissima* (Bohlmann et al. 1981b), *B. tola* (San Martin et al. 1982, 1983; Abad Martinez et al. 2005), *B. trinervis* (Arriaga et al. 1982), *B. vaccinioides* (Wollenweber et al. 1986), and *B. viminea* (Wollenweber et al. 1997). Its 8-hydroxylated derivative, isoscutellarein (**29**), was identified only in *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997), while the 4′-methylated derivative, acacetin (**30**), was found in aerial parts of *B. articulata* (Gianello and Giordano 1984; Cariddi et al. 2012), *B. conferta* (Weimann et al. 2002), and *B. polycephala* (Davila et al. 2013), in the leaf parts of *B. dracunculifolia* (Park et al. 2004; da Silva Filho et al. 2009) and *B. rhomboidalis* (Silva et al. 1971) and from *B. grandicapitulata* (Bohlmann et al. 1985), *B. patagonica* (Zdero et al. 1986; Rivera et al. 1988); *B. salicifolia* (Wollenweber et al. 1986), *B. trinervis* (Arriaga et al. 1982), *B. vaccinioides* (Wollenweber et al. 1986), and *B. viminea* (Wollenweber et al. 1997). Also other two monomethylated derivatives were found: genkwanin (**31**) in aerial parts of *B. crispa* (Palacios et al. 1983), *B. notosergila* (Palacios et al. 1983), *B. pedicellata* (Faine et al. 1987), *B. trimera* (Nakasugi 1990; Nakasugi and Komai 1998), in leaves of *B. trinervis* (Herrera et al. 1996) as well as from *B. genistelloides* (Abad Martinez et al. 2005; Hennig et al. 2011) and *B. pilularis* (Wollenweber et al. 1997). Thevetiaflavone (**32**) was identified in aerial parts of *B. gaudichaudiana* (Guo et al. 2007; Campos et al. 2016). 4′,5- and 4′,7- dimethylated derivatives (**33** and **34** derivatives, respectively) were identified in some *Baccharis* species, 7-Hydroxy-5,4′-dimethoxyflavone (**33**) was isolated from aerial parts of *B. articulata* (de Oliveira et al. 2014) and *B. usterii* (Salcedo Ortiz et al. 2001), while 5-Hydroxy-4′,7-dimethoxyflavone **(34)**, from aerial parts of *B. conferta* (Weimann et al. 2002), *B. crispa* (Bandoni et al. 1978), *B. illinita* (Pizzolatti et al. 2006; Campos et al. 2016), from leaves of *B. rhomboidalis* (Silva et al. 1971), *B. teindalensis* (Vidari et al. 2003), *B. tola* (San Martin et al. 1982), *B. trinervis* (Herrera et al. 1996), and from *B. latifolia* (Salcedo Ortiz et al. 2001). Flavones biosynthesized from phenylalanine-cinnamic acid-pinocembrin were also identified: chrysin (**35**) and 7-methylchrysin (**36**) from leaves of *B. dracunculifolia* (Park et al. 2004; Paula et al. 2017) and *B. viminea* (Wollenweber et al. 1997). Its 2′-methoxylated derivative, 2′-methoxychrysin (**37**), was also identified from flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016). Hispidulin (**38**) was identified in aerial parts of *B. flabellata* (Saad et al. 1988), *B. gaudichaudiana* (Fullas et al. 1994; Akaike et al. 2003; Campos et al. 2016), *B. genistelloides* (Daily et al. 1984; San Martin et al. 2012), *B. grisebachii* (Tapia et al. 2004; Abad and Bermejo 2007), *B. halimifolia* (Joshi et al. 1997; Jakupovic et al. 1990), *B. ligustrina* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Nogueira Sobrinho et al. 2016), *B. magellanica* (Cordano et al. 1982), *B. rhomboidalis* (Labbe et al. 1986), *B. trimera* (Soicke and Leng-Eschlow 1987; Nakasugi 1990; Nakasugi and Komai 1998; Padua et al. 2014), and *B. uncinella* (Grecco et al. 2010a, b, 2014a, b; Campos et al. 2016). Flavonoid **38** was also identified in leaves and shrub of *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016) and nonspecified parts of *B. vaccinioides* (Wollenweber et al. 1986). Pectolinaringenin (**39**) was identified in aerial parts of *B. concava* (Zamorano et al. 1987), *B. conferta* (Weimann et al. 2002), *B. decussata* (Morales Mendez et al. 1984; Rojas and Morales 2000), *B. grisebachii* (Gianello and Giordano 1987; Feresin et al. 2003; Abad Martinez et al. 2005), and *B. uncinella* (Grecco et al. 2010a, b, 2014a, b; Passero et al. 2011; Zalewski et al. 2011; Campos et al. 2016). Flavonoid **(39)** was also detected in the leaves of *B. pedunculata* (Rahalison et al. 1995), branches of *B. trinervis* (Sharp et al. 2000; Abad Martinez et al. 2005) [44, 103], and nonspecified parts of fresh *B. macraei* (Faini et al. 1991) [104], *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997) [41] and *B. vaccinioides* (Wollenweber et al. 1986). Cirsimaritin (**40**) was identified in the aerial parts of *B. concava* (Zamorano et al. 1987), *B. concinna*

(Wollenweber et al. 2006), *B. conferta* (Weimann et al. 2002), *B. genistelloides* (Suttisri et al. 1994; Abad Martinez et al. 2005; Hennig et al. 2011), *B. rhomboidalis* (Labbe et al. 1986), *B. rufescens* var. *rufescens* (Simirgiotis et al. 2003; Abad and Bermejo 2007; Campos et al. 2016), *B. trimera* (Nakasugi 1990; Nakasugi and Komai 1998), *B. elaeagnoides* (Mesquita et al. 1985), *B. halimifolia* (Joshi et al. 1997), *B. intermedia* and *B. macraei* (Faini et al. 1991), *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997), and *B. tricuneata* (Wagner et al. 1978). Scutellarein-7,4′-dimethyl ether (**41**) was identified from aerial parts of *B. tucumanensis* (Tonn et al. 1982), while salvigenin (**42**) was found in the aerial parts of *B. concava* (Zamorano et al. 1987), *B. conferta* (Weimann et al. 2002), *B. rhomboidalis* (Labbe et al. 1986), and *B. scandens* (Cabrera et al. 2016). Flavonoid **42** was identified in the branches of *B. trinervis* (Sharp et al. 2000; Abad Martinez et al. 2005), and in nonspecified parts of *B. macraei* (Faini et al. 1991) and *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). Desmethoxysudachitin (**43**) was identified in the aerial parts of *B. grisebachii* (Gianello and Giordano 1987; Tapia et al. 2004; Grecco et al. 2010a, b; Campos et al. 2016) and *B. solierii* (Labbe et al. 1986). Its 4′-methylated derivative, nevadensin (**44**), was found in the aerial parts of *B. decussata* (Rojas and Morales 2000), *B. grisebachii* (Gianello and Giordano 1987; Feresin et al. 2003; Tapia et al. 2004; Grecco et al. 2010a, b), and *B. nitida* (Chidiak et al. 2007; Campos et al. 2016). A methylated derivative of **43** in position C-7 afforded xantomicrol (**45**) found in aerial parts of *B. boliviensis* (Calle et al. 2012; Campos et al. 2016), *B. nitida* (Chidiak et al. 2007; Campos et al. 2016), *B. patens* (Silva et al. 1985), *B. scandens* (Cabrera et al. 2016), and *B. tucumanensis* (Tonn et al. 1982). Compound **45** was also found in the leaves of *B. pentlandii* (Tarqui et al. 2012) and roots of *B. quitensis* (Bohlmann et al. 1981b). Gardenin B (**46**) was identified in the aerial parts of *B. grisebachii* (Feresin et al. 2003; Tapia et al. 2004; Campos et al. 2016) and *B. scandens* (Cabrera et al. 2016). A pentamethoxylated derivative, tangeretin (**47**), was found in the flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016). The flavone luteolin (**48**), derived from dehydration of flavanone eriodictyol, was identified in aerial parts of *B. articulata* (Cariddi et al. 2012), *B. bigelovii* (Arriaga-Giner et al. 1986; Wollenweber et al. 1986), *B. concinna* (Wollenweber et al. 2006), *B. confertifolia* (Wollenweber et al. 2006), *B. gaudichaudiana* (Guo et al. 2007), *B. genistelloides* (San Martin et al. 2012), *B. incarum* (Zampini et al. 2009; Campos et al. 2016), *B. linearis* (Wollenweber et al. 2006), *B. lycioides* (Wollenweber et al. 2006), *B. reticularia* (Bohlmann et al. 1981a), *B. trimera* (Soicke and Leng-Eschlow 1987; da Silva et al. 2016; Menezes et al. 2016), *B. trinervis* (Jaramillo-Garcia et al. 2018), and *B. varians* (Bohlmann et al. 1981a). Furthermore, flavonoid **48** was isolated from flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016), and nonspecified parts of *B. halimifolia* (Wollenweber et al. 1997), *B. microcephala* (Bohlmann et al. 1985), *B. nitida* (Bohlmann et al. 1985), and *B. pteronioides* (Wollenweber et al. 1986). Methylated derivatives of luteolin, biosynthesized through luteolin-methyltransferase, were found in several studied *Baccharis* species. A monomethylated (C-3′) derivative, chrysoeriol (**49**), was identified in the flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al.

2016), shrub of *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016), and aerial parts of *B. salicifolia* (Warning et al. 1986). 4′,7- and 3′,7- Dimethylated derivatives of Luteolin were also found in *Baccharis* genus, luteolin-4′,7-dimethylether (**50**) in aerial parts of *B. trimera* (Padua et al. 2014; de Araujo et al. 2016), and leaves of *B. trinervis* (Herrera et al. 1996) and luteolin-3′,7-dimethylether (**51**) in aerial parts of *B. calliprinos* (Gianello et al. 1999), *B. rhetinodes* (Gianello et al. 1999), and *B. salicifolia* (Warning et al. 1986). The trimethylated derivative, 5-hydroxy-7,3′,4′-trimethoxyflavone/luteolin-3′,4′,7-trimethylether (**52**), was identified in the aerial parts of *B. crispa* (Bandoni et al. 1978) [80], *B. latifolia* (Salcedo et al. 2003; Campos et al. 2016), and in the leaves of *B. trinervis* (Herrera et al. 1996). 6-Hydroxyluteolin (**53**) was found only in aerial parts of *B. boliviensis* (Campos et al. 2016), while its methylated derivatives were identified in several *Baccharis* species; nepetin, also known as eupafolin (**54**), was identified in aerial parts of *B. concinna* (Wollenweber et al. 2006), *B. confertifolia* (Wollenweber et al. 2006), *B. flabellata* (Saad et al. 1988), *B. gaudichaudiana* (Akaike et al. 2003; Campos et al. 2016), *B. genistelloides* (San Martin et al. 2012), *B. linearis* (He 1995; He et al. 1996; Wollenweber et al. 2006), *B. lycioides* (Wollenweber et al. 2006), and *B. trimera* (Soicke and Leng-Eschlow 1987; Simões-Pires et al. 2005). Jaceosidin (**55**) was isolated from aerial parts of *B. concinna* (Wollenweber et al. 2006), *B. flabellata* (Saad et al. 1988), *B. gaudichaudiana* (Akaike et al. 2003; Campos et al. 2016), and *B. grisebachii* (Tapia et al. 2004). Desmethoxycentaureidin (**56**) was obtained from aerial parts of *B. gaudichaudiana* (Akaike et al. 2003; Campos et al. 2016), *B. solierii* (Labbe et al. 1986), and non-specified parts of *B. petiolata* (Labbé et al. 1990) and *B. salicina* (Parodi and Fischer 1988; Quijano et al. 1998). Cirsiliol (**57**) was identified in the aerial parts of *B. concinna* (Wollenweber et al. 2006), *B. confertifolia* (Wollenweber et al. 2006), *B. flabellata* (Saad et al. 1988), *B. linearis* (Wollenweber et al. 2006), *B. rufescens* var. *rufescens* (Simirgiotis et al. 2003; Abad and Bermejo 2007; Campos et al. 2016), and in nonspecified parts of *B. genistelloides* (Kuroyanagi et al. 1985; Abad Martinez et al. 2005; Hennig et al. 2011) and *B. tricuneata*. Cirsilineol (**58**) was detected in aerial parts of *B. concinna* (Wollenweber et al. 2006), *B. salicifolia* (Warning et al. 1986), and nonspecified parts of *B. genistelloides* (Abad Martinez et al. 2005; Hennig et al. 2011), while 5,6-dihydroxy-3′,4′,7-trimethoxyflavone (**59**) from young parts of *B. trimera* (Borella et al. 2006). The aerial parts of *B. conferta* (Weimann et al. 2002) and *B. gaudichaudiana* (Akaike et al. 2003; Campos et al. 2016) afforded eupatilin (**60**), while aerial parts of *B. genistelloides* (Suttisri et al. 1994; Hennig et al. 2011) and leaves, stems, flowers, and fruits of *B. trimera* (Herz et al. 1977; de Mello and Petrovick 2000; Torres et al. 2000; da Silva et al. 2004; Silva et al. 2006; Padua et al. 2014; de Araujo et al. 2016) afforded eupatorin (**61**). 5-Hydroxy-3′,4′,6,7-tetramethoxyflavone (**62**) was identified from aerial parts of *B. genistelloides* (Suttisri et al. 1994) and leaves of *B. trimera* (Rendon and Vila 1995; Silva et al. 2006). Sideritiflavone (**63**) was detected in aerial parts of *B. patens* (Silva et al. 1985) and *B. thymifolia* (Saad et al. 1987) as well as from leaves of *B. pentlandii* (Tarqui et al. 2012; Campos et al. 2016;). 4′,5-Dihydroxy-3′,6,7,8-tetramethoxyflavone (**64**), known as 7-methylsudachitin or 3′-methoxyxanthomicrol, was identified from aerial parts of *B. incarum* (Faini et al. 1982a, b), *B. salicifolia*

(Warning et al. 1986) and *B. thymifolia* (Saad et al. 1987), from leaves of *B. pentlandii* (Tarqui et al. 2012; Campos et al. 2016), and roots of *B. oxyodonta* and *B. quitensis* (Bohlmann et al. 1981b). Gardenin D (**65**) was identified in aerial parts of *B. patens* (Silva et al. 1985). A pentamethoxylated derivative, 5-hydroxy-3′,4′,6,7,8-pentamethoxytlavone (**66**), was detected only in aerial parts of *B. thymifolia* (Saad et al. 1987). Nobiletin was identified only in the flowers of *B. illinita* (**67**). Although in less distribution, flavone glycosides were found in *Baccharis* species: isoschaftoside (**68**) was identified in the aerial parts of *B. gaudichaudiana* (Akaike et al. 2003; Campos et al. 2016), while vicenin II (**69**), 6(8)-C-furanosyl-8(6)-C-hexosyl flavone (**70**), 6(8)-C-hexosyl-8(6)-C-furanosyl flavone (**71**), and 5,3′-dihydroxy-4′-methoxy-7-O-pyranosyl-furanosyl flavone (**72**) were detected in the aerial parts of *B. trimera* (Padua et al. 2014; de Araujo et al. 2016; Rabelo et al. 2017). Flavones identified in *Baccharis* species are summarized in Table 11.3, followed by their respective structures in Fig. 11.7.



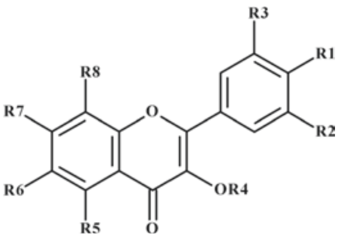
28 - R1 = R4 = R6 = OH; R2 = R3 = R5 = R7 = H
29 - R1 = R4 = R6 = R7 = OH; R2 = R3 = R5 = H
30 - R1 = OMe; R4 = R6 = OH; R2 = R3 = R5 = R7 = H
31 - R1 = R4 = OH; R6 = OMe; R2 = R3 = R5 = R7 = H
32 - R1 = R6 = OH; R4 = OMe; R2 = R3 = R5 = R7 = H
33 - R1 = R4 = OMe; R6 = OH; R2 = R3 = R5 = R7 = H
34 - R1 = R6 = OMe; R4 = OH; R2 = R3 = R5 = R7 = H
35 - R4 = R6 = OH; R1 = R2 = R3 = R5 = R7 = H
36 - R4 = OH; R6 = OMe; R1 = R2 = R3 = R5 = R7 = H
37 - R3 = OMe; R4 = R6 = OH; R1 = R2 = R5 = R7 = H
38 - R1 = R4 = R6 = OH; R5 = OMe; R2 = R3 = R7 = H
39 - R1 = R5 = OMe; R4 = R6 = OH; R2 = R3 = R7 = H
40 - R1 = R4 = OH; R5 = R6 = OMe; R2 = R3 = R7 = H
41 - R1 = R6 = OMe; R4 = R5 = OH; R2 = R3 = R7 = H
42 - R1 = R5 = R6 = OMe; R4 = OH; R2 = R3 = R7 = H
43 - R1 = R4 = R6 = OH; R5 = R7 = OMe; R2 = R3 = H
44 - R1 = R5 = R7 = OMe; R4 = R6 = OH; R2 = R3 = H
45 - R1 = R4 = OH; R5 = R6 = R7 = OMe; R2 = R3 = H
46 - R1 = R5 = R6 = R7 = OMe; R4 = OH; R2 = R3 = H
47 - R1 = R4 = R5 = R6 = R7 = OMe; R2 = R3 = H
48 - R1 = R2 = R4 = R6 = OH; R3 = R5 = R7 = H
49 - R1 = R4 = R6 = OH; R2 = OMe; R3 = R5 = R7 = H
50 - R1 = R6 = OMe; R2 = R4 = OH; R3 = R5 = R7 = H
51 - R1 = R4 = OH; R2 = R6 = OMe; R3 = R5 = R7 = H
52 - R1 = R2 = R6 = OMe; R4 = OH; R3 = R5 = R7 = H
53 - R1 = R2 = R4 = R5 = R6 = OH; R3 = R7 = H
54 - R1 = R2 = R4 = R6 = OH; R5 = OMe; R3 = R7 = H
55 - R1 = R4 = R6 = OH; R2 = R5 = OMe; R3 = R7 = H
56 - R1 = R5 = OMe; R2 = R4 = R6 = OH; R3 = R7 = H
57 - R1 = R2 = R4 = OH; R5 = R6 = OMe; R3 = R7 = H
58 - R1 = R6 = OMe; R2 = R4 = R5 = OH; R3 = R7 = H
59 - R1 = R2 = R6 = OMe; R4 = R5 = OH; R3 = R7 = H
60 - R1 = R2 = R5 = OMe; R4 = R6 = OH; R3 = R7 = H
61 - R1 = R5 = R6 = OMe; R2 = R4 = OH; R3 = R7 = H
62 - R1 = R2 = R5 = R6 = OMe; R4 = OH; R3 = R7 = H
63 - R1 = R2 = R4 = OH; R5 = R6 = R7 = OMe; R3 = H
64 - R1 = R4 = OH; R2 = R5 = R6 = R7 = OMe; R3 = H
65 - R1 = R5 = R6 = R7 = OMe; R2 = R4 = OH; R3 = H
66 - R1 = R2 = R5 = R6 = R7 = OMe; R4 = OH; R3 = H
67 - R1 = R2 = R4 = R5 = R6 = R7 = OMe; R3 = H
68 - R1 = R4 = R6 = OH; R5 = Ara; R7 = Glu; R2 = R3 = H
69 - R1 = R4 = R6 = OH; R5 = R7 = Glu; R2 = R3 = H
70 - R5 = Furanosyl; R7 = Hexosyl; R1 = R2 = R3 = R4 = R6 = H
71 - R5 = Hexosyl; R7 = Furanosyl; R1 = R2 = R3 = R4 = R6 = H
72 - R1 = OMe; R2 = R4 = OH; R6 = O-Pyranosyl-Furanosyl; R3 = R5 = R7 = H

Fig. 11.7 Structures of flavones **28**–**72** identified in *Baccharis* species

7 Flavanols

The biosynthesis of flavanols, the main group of flavonoids of genus *Baccharis*, occurs after the formation of flavanonols, through flavanol synthase enzyme (FLS). Thus, naringenin (**1**) is converted to aromadendrin/dihydrokaempferol (**17**) to finally afford the flavanol kaempferol (**73**). Compound **73** was identified in aerial parts of *B. conferta* (Weimann et al. 2002), *B. dentata* (Sartor et al. 2013; Campos et al. 2016), *B. gaudichaudiana* (Campos et al. 2016), *B. polycephala* (Davila et al. 2013), *B. trimera* (da Silva et al. 2016), and *B. retusa* (Campos et al. 2016; Grecco et al. 2012a). This compound was also identified in the flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016), flowering tops of *B. maritima* (Moreira et al. 1975), leaves of *B. pseudotenuifolia* (Moreira et al. 2003a, b; Campos et al. 2016), and buds, stems, and vegetative gems of *B. dracunculifolia* (Palacios et al. 1983; Park et al. 2004, 2005; de Alencar et al. 2005) and nonspecified parts of *B. genistelloides* (Daily et al. 1984), and *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). The 3-methylation of kaempferol afforded isokaempferide (**74**) identified in the aerial parts of *B. linearis* (Faini et al. 1999; Wollenweber et al. 2006), *B. lycioides* (Wollenweber et al. 2006), and *B. pedicellata* (Faine et al. 1987). Furthermore, this compound was also identfiied in the leaves of *B. papillosa* (Escobar et al. 2009; Campos et al. 2016), and nonspecified parts of fresh *B. intermedia* (Faini et al. 1991), *B. linearis* (Faini et al. 1991), *B. macraei* (Faini et al. 1991), and *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). The 4′-methylation affords kaempferide (**75**), found in aerial parts of *B. conferta* (Weimann et al. 2002) and *B. polycephala* (Davila et al. 2013) as well as in the flowers, leaves, buds, stems, and vegetative gems of *B. dracunculifolia* (Midorikawa et al. 2003; Park et al. 2004, 2005; de Alencar et al. 2005; Piantino et al. 2008; Campos et al. 2016; Paula et al. 2017), in no-nspecified parts of *B. leptophylla* (Almanza et al. 2000; Mollinedo et al. 2001) and in *B. pilularis* var. *consanguinea* and *B. viminea* (Wollenweber et al. 1997). Kaempferol-7-methyleter (**76**) was identified only in *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). The leaves of *B. papillosa* (Campos et al. 2016) afforded emanin (**77**), also identified in buds, leaves, and stems of *B. dracunculifolia* (Midorikawa et al. 2003; da Silva Filho et al. 2009) and from nonspecified parts of *B. pilularis* var. *consanguinea* and from *B. viminea* (Wollenweber et al. 1997). Kaempferol-7,4′-dimethyl ether (**78**) was detected in the aerial parts of *B. crispa* (Bandoni et al. 1978) and *B. illinita* (Pizzolatti et al. 2006; Campos et al. 2016) as well as from leaves of *B. teindalensis* (Vidari et al. 2003). Kaempferol-3,7-dimethyl ether (**79**) was identified in the aerial parts of *B. pedicellata* (Faine et al. 1987) and *B. santelicis* (Zdero et al. 1991) and nonspecified parts of *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). The trimethylated derivative, kaempferol-3,4′,7-trimethylether (**80**), was identified in the aerial parts of *B. illinita* (Pizzolatti et al. 2006; Campos et al. 2016) and *B. santelicis* (Zdero et al. 1991). Galangin (**81**) was detected in the leaf bud of *B. dracunculifolia* (Park et al. 2005) and nonspecified parts of *B. viminea* (Wollenweber et al. 1997), that also afforded galangin-7-methyleter (**82**). 6-Hydroxylated kaempferol and its derivatives were identified in few *Baccharis* species, 6-hydroxykaempferol (**83**) in *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997); 6-methoxykaempferol (**84**) in leaves of *B. dracunculifolia* (Kumazawa et al. 2003); 4′,6-dimethoxykaempferol (**85**) in aerial parts of *B. conferta* (Weimann et al. 2002); and 6,7-dimethoxykaempferol (**86**) in *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). Penduletin (**87**) was identified in leaves of *B. pedunculata* (Rahalison et al. 1995), branches of *B. trinervis* (Sharp et al. 2000; Abad Martinez et al. 2005), and nonspecified parts of *B. salicifolia*, *B. sarothroides* and *B. vaccinioides* (Wollenweber et al. 1986), while herbacetin-3-methylether (**88**) was isolated from *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). Quercetin (**89**) was identified in the aerial parts of *B. articulata* (Campos et al. 2016), *B. bigelovii* (Arriaga-Giner et al. 1986; Wollenweber et al. 1986), *B. concinna* and *B. confertifolia* (Wollenweber et al. 2006), *B. dentata* (Sartor et al. 2013; Campos et al. 2016), *B. genistelloides* (Daily et al. 1984; San Martin et al. 2012), *B. grisebachii* (Tapia et al. 2004), *B. linearis* (Wollenweber et al. 2006, *B. lycioides* (Wollenweber et al. 2006), *B. pteronioides*, *B. retusa*, *B. salicifolia* (Wollenweber et al. 1986), *B. scandens* (Cabrera et al. 2016), *B. thesioides* (Liu et al. 1993), *B. trimera* (Soicke and Leng-Eschlow 1987; Simões-Pires et al. 2005; Padua et al. 2014; da Silva et al. 2016; de Araujo et al. 2016; Menezes et al. 2016; Sabir et al. 2017), *B. trinervis* (Jaramillo-Garcia et al. 2018), in the leaf bud of *B. dracunculifolia* (Park et al. 2005), leaves and shrubs of *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016), leaves, stems, and flowers of *B. spicata* (Agudelo et al. 2016) flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016) and *B. maritima* (Moreira et al. 1975) as well as in the nonspecified parts of *B. viminea* (Wollenweber et al. 1997). Rhamnetin (**90**) was detected in leaves and stems of *B. confertifolia* (Wollenweber et al. 2006) and nonspecified parts of *B. pilularis var. consanguinea* (Wollenweber et al. 1997), while isorhamnetin (**91**) was detected in the aerial parts of *B. tola*, leaves and stems of *B. linearis* (He 1995; Wollenweber et al. 2006) and *B. lycioides* (Wollenweber et al. 2006), leaves and shrubs of *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016), and in nonspecified parts of *B. viminea* (Wollenweber et al. 1997). The 3-methylated derivative of quercetin, 3-methylquercetin (**92**), was identified in the aerial parts of *B. tola* (Simirgiotis et al. 2016) and *B. trimera* (de Mello and Petrovick 2000), in the leaves of *B. linearis* (Faini et al. 1999), flowers of *B. illinita* (Verdi et al. 2004; Abad and Bermejo 2007; Campos et al. 2016), fresh parts of *B. intermedia* and *B. linearis* (Faini et al. 1991) as well as in the nonspecified parts of *B. halimifolia* (Wollenweber et al. 1997). Rhamnazin (**93**) was found in the aerial parts of *B. tola* (Simirgiotis et al. 2016), leaves and stems of *B. confertifolia* (Wollenweber et al. 2006), and nonspecified parts of *B. latifolia* (Salcedo et al. 2001). Isorhamnetin 3-methylether (**94**) was identified in the aerial parts of *B. tola* (Simirgiotis et al. 2016), leaves and stems of *B. linearis* (Faini et al. 1999; Wollenweber et al. 2006) and *B. lycioides* (Wollenweber et al. 2006), and in the nonspecified parts of fresh *B. intermedia* and *B. linearis* (Faini et al. 1991). *B. sarothroides* afforded 3,4′-dimethoxy-3′,5,7-trihydroxyflavone (**95**) (Abad Martinez et al. 2005), while 3,7-dimethoxyquercetin (**96**) was found in aerial parts of *B. triangularis* (Gianello and Giordano 1989) and nonspecified parts of *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). 3,7-Dimethylisorhamnetin (**97**) was isolated from aerial parts of *B. tola* (Simirgiotis et al. 2016), while 3,7,4′-trimethylquercetin (**98**) was obtained from leaves and stems of *B. illinita* (Campos et al. 2016) and nonspecified parts of *B. grisebachii* (Abad and Bermejo 2007). 3,5-dihydroxy-7,3′,4′-trimethoxyflavone (**99**) was detected in *B. latifolia*. Retusin (**100**) was isolated from leaves and stems of *B. illinita* (Pizzolatti et al. 2006; Campos et al. 2016), while 3-hydroxy-5,7,3′,4’tetrameth oxyflavone (**101**) was obtained from aerial parts of *B. latifolia* (Salcedo et al. 2003; Campos et al. 2016) and *B. conferta* (Weimann et al. 2002). Patuletin (**102**) was detected in leaves and stems of *B. concinna* and *B. confertifolia* (Wollenweber et al. 2006) as well as in nonspecified parts of *B. halimifolia* and *B. pilularis* var. *consanguinea* (Wollenweber et al. 1997). Flavonoid 3′-methylpatuletin (**103**) was detected in *B. halimifolia* (Wollenweber et al. 1997), while axillarin (**104**) was identified in the leaves and stems of *B. incarum* (Campos et al. 2016), *B. linearis* (Labbe et al. 1986; Wollenweber et al. 2006), and *B. solierii* (Labbe et al. 1986) as well as in the nonspecified parts of *B. halimifolia* (Wollenweber et al. 1997). Eupatolitin (**105**) was isolated from leaves and stems of *B. confertifolia* (Wollenweber et al. 2006) and aerial parts of *B. gaudichaudiana* (Akaike et al. 2003). Centaureidin (**106**) was identified in the leaves and twigs of *B. sarothroides* (Montes et al. 1971; Abad Martinez et al. 2005), leaves and stems of *B. solierii* (Labbe et al. 1986), and nonspecified parts of *B. salicina* (Parodi and Fischer 1988; Quijano et al. 1998). 5,7-Dihydroxy-3,6,3′,4′-tetramethoxyflavone (**107**) was detected in *B. salicina* (Quijano et al. 1998), while three gossypetin derivatives (**108–110**) were identified in leaves and stems of *B. linearis* (Wollenweber et al. 2006): 3,3′-dimethyl- (**108**), 3,8-dimethyl- (**109**) and 3,8,3′-trimethyl-(**110**) derivatives. 3′,4′,5,7-Tetrahydroxy-3,6,8-trimethoxyflavone (**111**) and 4′,5,7-trihydroxy-3,3′,6,8-tetramethoxyflavone (**112**) were identified in the leaves and stems of *B. incarum* (Campos et al. 2016); compound **112** was also identified in the leaves and stems of *B. solierii* (Labbe et al. 1986). 3′,5-Dihydroxy-3,4′,6,7,8-pentamethoxyflavone (**113**) was detected in the aerial parts of *B. boliviensis* (Campos et al. 2016) and 4′,5-dihydroxy3′,,3,6,7,8-pentamethoxyflavone (**114**) in the leaves and stems of *B. incarum* (Faini et al. 1982a, b; Nuño et al. 2012; Campos et al. 2016). Six myricetin derivatives (**115–120**) were detected in leaves and stems of *B. tola* (Simirgiotis et al. 2016): 3-O-acetyl- (**115**), 7,3′-dimethyl- (**116**), 7,3′,5′-trimethyl- (**117**), 3′,5′,7,8-tetramethyl- (**118**), 6-hydroxy-7,3′,5′-trimethyl – (**119**) and 6-hydroxy-3,7,3′,5′-tetramethyl (**120**) derivatives. Additionally, nine flavonol glycosides (**121–129**) were identified in several species of *Baccharis*: apigenin 3-O-β-D-glucopyranoside, also known as astragalin (**121**), from aerial parts of *B. dracunculifolia* (Nagatani et al. 2001) and from *B. angustifolia* (Wagner et al. 1972), kaempferol-3-O-rutinoside, also known as nicotiflorin (**122**), from *B. antioquensis* (Mejia-Giraldo et al. 2016), quercetin 3-O-[β-D-apiofuranosyl-(1 → 2) α-Lrhamnopyranosyl-(1 → 6)]-β-D-glucopyranoside (**123**) from *B. thesioides* (Liu et al. 1993), isoquercetin (**124**) from aerial parts of *B. dracunculifolia* (Nagatani et al. 2001), *B. thesioides* (Kakehashu et al. 2016), *B. trimera* (Simões-Pires et al. 2005), *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016), *B. angustifolia* (Wagner et al. 1972), and *B. ochracea* (Schenkel et al. 1997). Hyperoside (**125**) was detected in the aerial parts of *B. dracunculifolia* (Nagatani et al. 2001) and *B. thesioides* (Liu et al. 1993) [144], while quercitrin (**126**) was identified in *B. gaudichaudiana* (Akaike et al. 2003; Campos et al. 2016), *B. microdonta* (Toyama et al. 2014), and *B. pseudotenuifolia* (Moreira et al. 2003a, b; Abad and Bermejo 2007; Campos et al. 2016). Rutin (**127**) was identified in the aerial parts of *B. gaudichaudiana* (Akaike et al. 2003; Campos et al. 2016), *B. thesioides* (Liu et al. 1993), *B. trinervis* (Jaramillo-Garcia et al. 2018), and *B. trimera* (Gene et al. 1996; Menezes et al. 2016; Sabir et al. 2017). Furthermore, flavonoid **127** was also isolated from leaves of *B. antioquensis* (Mejia-Giraldo et al. 2016), leaves and stems of *B. dentata* (Sartor et al. 2013; Campos et al. 2016), leaves, stems, and flowers *B. spicata* (Agudelo et al. 2016), and nonspecified parts of *B. genistelloides* (Hennig et al. 2011). Finally, quercetin-3-O-(4‴-O-caffeoyl)-rhamnopyranosyl-(1 → 6)-galactopyranoside (**128**) was identified in the leaves of *B. antioquensis* (Mejia-Giraldo et al. 2016). Flavanols identified in *Baccharis* species are summarized in Table 11.4, followed by their respective structures in Fig. 11.8.

Flavonoids display a significant role in biological functions, especially those that depend on the modulation of redox balance. Several studies describes the antioxidant and radical scavenger activities of extracts and isolated flavonoids of *Baccharis*, such as the antioxidant activities of isosakuranetin (**3**), dihydrokaempferide (**19**), kaempferol (**75**) (Mollinedo et al. 2001), isokaempferide (**74**), ermanin (**77**), 3-methylquercetin (**92**) (Escobar et al. 2009), luteolin (**48**), axillarin (**104**), 3′,4′,5,7-tetrahydroxy-3,6,8-trimethoxyflavone (**111**), 4′,5,7-trihydroxy-3,3′,6,8-tetramethoxyflavone (**112**), and 4′,5-dihydroxy-3′,3,6,7,8-pentamethoxyflavone (**114**). Antioxidant activities were also attributed to extracts of *B. spicata*, *B. tola*,



73 - R1= R5= R7= OH; R2= R3= R4= R6= R8= H
74 - R1= R5= R7= OH; R4= OMe; R2= R3= R6= R8 = H
75 - R1 = OMe; R5 = R7 = OH; R2 = R3 = R4 = R6 = R8 = H
76 - R1= R5= OH; R7= OMe; R2= R3= R4= R6= R8= H
77 - R1= OMe; R4= Me; R5= R7= OH; R2= R3= R6= R8= H
78 - R1= R7= OMe; R5= OH; R2= R3= R4=R6= R8= H
79 - R4= Me; R7= OMe; R1= R5= OH; R2= R3= R6= R8= H
80 - R1= R7= OMe; R4= Me; R5= OH; R2= R3= R6= R8= H
81 - R5= R7= OH; R1= R2= R3= R4= R6= R8= H
82 - R5= OH; R7= OMe; R1= R2= R3= R4= R6= R8= H
83 - R1= R5= R6= R7= OH; R2= R3= R4= R8= H
84 - R1= R5= R7= OH; R6= OMe; R2= R3= R4= R8= H
85 - R1= R6= OMe; R5= R7= OH; R2= R3= R4= R8= H
86 - R1= R5= OH; R6= R7= OMe; R2= R3= R4= R8= H
87 - R1= R5= OH; R4= Me; R6= R7= OMe; R2= R3= R4= R8= H
88 - R1= R5= R7= R8= OH; R4= Me; R2= R3= R6= H
89 - R1= R2= R5= R7= OH; R3= R4= R6= R8= H
90 - R1= R2= R5= OH; R7= OMe; R3= R4= R6= R8= H
91 - R1= R5= R7= OH; R2= OMe; R3= R4= R6= R8= H
92 - R1= R2= R5= R7= OH; R4= Me; R3= R6= R8= H
93 - R1= R5= OH; R2= R7= OMe; R3= R4= R6= R8= H
94 - R1= R5= R7= OH; R2= OMe; R4= Me; R3= R6= R8= H
95 - R1= OMe; R2= R5= R7= OH; R4= Me; R3= R6= R8= H
96 - R1= R2= R5= OH; R4= Me; R7= OMe; R3= R6= R8= H
97 - R1= R5= OH; R2= R7= OMe; R4= Me; R3= R6= R8= H
98 - R1= R7= OMe; R2= R5= OH; R4=Me; R3= R6= R8= H
99 - R1= R2= R7= OMe; R5= OH; R3= R4= R6= R8= H
100 - R1= R2= R7= OMe; R4= Me; R5= OH; R3= R6= R8= H
101 - R1= R2= R7= R5= OMe; R3= R4= R6= R8= H
102 - R1= R2= R5= R7= OH; R6= OMe; R3= R4= R8= H
103 - R1= R5= R7= OH; R2= R6= OMe; R3= R4= R8= H
104 - R1= R2= R5= R7= OH; R4= Me; R6= OMe; R3= R8= H
105 - R1= R2= R5= OH; R6= R7= OMe; R3= R4= R8= H
106 - R1= R6= OMe; R2= R5= R7= OH; R4= Me; R3= R8= H
107 - R1= R2= R6= OMe; R5= R7= OH; R4= Me; R3= R8= H
108 - R1= R5= R7= R8= OH; R2= OMe; R4= Me; R3= R6= H
109 - R1= R2= R5= R7= OH; R4= Me; R8= OMe; R3= R6= H
110 - R1= R5= R7= OH; R2= R8= OMe; R4= Me; R3= R6= H
111 - R1= R2= R5=R7= OH; R4= Me; R6= R8= OMe; R3= H
112 - R1= R5=R7= OH; R2= R6= R8= OMe; R4= Me; R3= H
113 - R1= R6= R7= R8= OMe; R2= R5= OH; R4= Me; R3= H
114 - R1= R5= OH; R2= R6= R7= R8= OMe; R4= Me; R3= H
115 - R1= R2= R3= R5= R7= OH; R4= Acyl; R6= R8= H
116 - R1= R3= R5= OH; R2= R7= OMe; R4= R6= R8= H
117 - R1= R5= OH; R2= R3= R7= OMe; R4= R6= R8= H
118 - R1= R5= OH; R2= R3= R7= OMe; R8= Me; R4= R6= H
119 - R1= R5= R6= OH; R2= R3= R7= OMe; R4= R8= H
120 - R1= R5= R6= OH; R2= R3= R7= OMe; R4= Me; R8= H
121 - R1= R5= R7= OH; R4= Glu;R2= R3= R6= R8= H
122 - R1= R5= R7= OH; R4= Rha-Glu;R2= R3= R6= R8= H
123 - R1= R2= R5= R7= OH; R4= (Apio)-Rha-Glu; R3= R6= R8= H
124 - R1= R2= R5= R7= OH; R4= Glu; R3= R6= R8= H
125 - R1= R2= R5= R7= OH; R4= Gal; R3= R6= R8= H
126 - R1= R2= R5= R7= OH; R4= Rha; R3= R6= R8= H
127 - R1= R2= R5= R7= OH; R4= Rha-Glu; R3= R6= R8= H
128 – R1= R2= R5= R7= OH; R4= Rha-Glu-caffeoyl; R3= R6= R8= H

Fig. 11.8 Structures of flavanols **73–128** identified in *Baccharis* species Biological activities and *B. trimera* (Agudelo et al. 2016; Simirgiotis et al. 2016; Sabir et al. 2017), while radical scavenger activity (DPPH, ROS) was attributed to *B. dentata* and *B. trimera* extracts (Sartor et al. 2013; Agudelo et al. 2016; Sabir et al. 2017). The last extract also inhibits ROS production through PKC and downregulates p47phox phosphorylation of NADPH oxidase in SK Hep-1 cells. Hispidulin (**38**), desmethoxysudachitin (**43**), jaceosidin (**55**), and quercetin (**89**) suppress/scavenge erythrocyte lipoperoxidation, **38** and **89** superoxide anions, and **89** DPPH (Tapia et al. 2004). Eupafolin (**54**), quercitrin (**127**), and rutin (**128**) moderately scavenge DPPH radical (Akaike et al. 2003). Compounds **48**, **104**, **111**, **112,** and **114** also displayed antimicrobial activity against methicillin-resistant *Staphylococcus aureus* and *Enterococcus faecalis* (Zampini et al. 2009; Nuño et al. 2012). Antimicrobial activities were also attributed to some flavonoids: penduletin (**87**) presented antifungal activity against some human pathogenic and phytopathogenic fungi (Rahalison et al. 1995). Isosakuranetin (**3**) showed antifungal activities against *Neurospora crassa* (Almanza et al. 2000) and *Cryptococcus neoformans* (da Silva Filho et al. 2008); besides the antioxidant activity, previously described, compound **3** also demonstrated strong trypanocidal (da Silva Filho et al. 2004) and antiinflammatory activities (Figueiredo-Rinhel et al. 2013); both activities were also attributed to dihydrokaempferide (**19**). *B. dentata* extracts presented antibacterial activity against *Staphylococcus aureus* (Sartor et al. 2013), while *B. crispa* and *B. notosergila* ethanolic extracts presented antimicrobial activities against *Bacillus subtilis*, *Micrococcus luteus*, and *Staphylococcus aureus*, due to the presence of genkwanin (**31**) and apigenin (**28**). Sakuranetin (**2**) presented antifungal activity against pathogenic yeast belonging to the genus *Candida* (six species – *C. dubliniensis, C. tropicalis, C. glabrata, C. parapsilosis, C. krusei, and C. albicans*), *Cryptococcus* (two species/four serotypes – *C. neoformans* – serotypes A and D, *C. gattii* – serotypes B and *C. neoformans*), and *Saccharomyces cerevisiae* (Grecco et al. 2014a, b). Compound **2** demonstrated promising activities to prevent and treat several respiratory disorders, such as acute lung injury (Bittencourt-Mernak et al. 2017), chronic allergic pulmonary inflammation (Sakoda et al. 2016), emphysema, through regulation of NF-κB, oxidative stress, and metalloproteinases (Taguchi et al. 2015a, b),and reverses airway inflammation and remodelling in an asthma murine model (Toledo et al. 2013). Sakuranetin (**2**) displayed activity against four *Leishmania* species (*L. amazonensis, L. braziliensis, L. major,* and *L. chagasi*) and *Trypanosoma cruzi* (Davila et al. 2013) and also presented phytotoxic activities against *Panicum miliaceum* and *Raphanus sativus*, inhibiting its growth and germination (del Corral et al. 2012). Pectolinaringenin (**39**) and cirsimaritin (**40**) present spasmolytic activities (Weimann et al. 2002) and antiparasitic potential (antileishmanial and trypanocidal). This was attributed to 5,6,7-trihydroxy-4′-methoxyflavanone (**4**), hispidulin (**38**), spectolinaringenin (**39**), acacetin (**30**), and ermanin (**77**) (da Silva Filho et al. 2009; Passero et al. 2011; Grecco et al. 2010a, b, 2014a, b). Luteolin-3′,7-dimethylether (**51**) displayed anti-inflammatory activity (Gianello et al. 1999), which was also attributed to rutin (**128**), within its analgesic effect (Gene et al. 1996) and pectolinaringenin (**39**) (Zalewski et al. 2011). *B. gaudichaudiana* and *B. spicata* presented antiviral activities against poliovirus type 2 (PV2) and vesicular stomatitis virus; PV2 attributed to the presence of apigenin (**28**) (Visintini et al. 2013) This compound also enhances the action of nerve growth factor to stimulate neurite outgrowth from PC12D cells, that could be useful in the treatment of neurological disorders (Guo et al. 2007). *B. articulata* extract induced the death of human peripheral blood mononuclear cells (PBMCs) through apoptosis and exerted low mutagenic effects on mice, those could be related to the presence of luteolin (**48**) and acacetin (**30**) and other nonflavonoidic compounds (Cariddi et al. 2012). Antitumoral activities were attributed to 3,4′-dimethoxy-3′,5,7-trihydroxyflavone (**95**) and centaureidin (**106**) (Montes et al. 1971), while gardenin B (**46**) demonstrated cytotoxic activities against HL60 and U937 – human leukemia cell lines, leading to activation of extrinsic and the intrinsic apoptotic pathways (Cabrera et al. 2016). Kaempferol and quercetin glycosides (**123**, **128** and **129**) from *B. antioquensis* displayed photoprotective potential, while quercitrin (**127**) displayed antivenom effect (*Crotalus durissus terrificus* snake) through inhibition of sPLA2 enzyme, preventing myotoxicity and edematogenic effect. Genkwanin (**31**), cirsimaritin (**40**), hispidulin (**38**), and apigenin (**28**) showed antimutagenic activity (Nakasugi and Komai 1998), while quercetin (**89**), luteolin (**48**), nepetin (**54**), apigenin (**28**), and hispidulin (**38**) were responsible for antihepatotoxic properties of *B. trimera* (Soicke and Leng-Eschlow 1987), leading to a protective effect against acute hepatic injury induced by acetaminophen (Padua et al. 2014), an effect also detected in *B. dracunculifolia* leaves extract (Rezende et al. 2014). *B. teindalensis* displayed antiulcer and antidiarrhoeic effects (Vidari et al. 2003), also observed for *B. dracunculifolia* extracts, with inhibition of doxorubicin-induced mutagenicity (Resende et al. 2007). Finally, stems of *B. illinita* presented anticoagulant activity, leading to a significant effect on platelet aggregation (Pizzolatti et al. 2006) and *B. trinervis* displayed cytotoxic, genotoxic, and mutagenic activities that could be related to the presence of flavonoids (Jaramillo-Garcia et al. 2018).

References

Abad MJ, Bermejo P (2007) *Baccharis* (Compositae): a review update. ARKIVOC 7:76–96. https://doi.org/10.3998/ark.5550190.0008.709

Abad Martinez MJ, Bessa AL, Benito PB (2005) Biologically active substances from the genus *Baccharis* L. (Compositae). Stud Nat Prod Chem 30:703–759. https://doi.org/10.1016/s1572-5995(05)80045-6

Agudelo IJ, Isolabella AS, Filip R et al (2016) *Baccharis spicata* (lam) baill: polyphenol screening, determination of their antioxidant activity and their main polyphenolic metabolites. J Pharmacogn Phytochem 5:278–285

Akaike S, Sumino M, Sekine T et al (2003) A new Ent-clerodane diterpene from the aerial parts of *Baccharis gaudichaudiana*. Chem Pharm Bull 51:197–199. https://doi.org/10.1248/cpb.51.197

Almanza GR, Arduz C, Balderrama L et al (2000) Phytochemical study of *Baccharis leptophylla* bioguided against *Neurospora crassa*. Boliv J Chem 17:1–8

Arriaga FJG, Borges JC, Manresa MTF et al (1982) Compounds from salvadoran plants. III. Components of *Baccharis trinervis* Persoon. Rev Latinoam Quím 13:47–49

Arriaga-Giner FJ, Wollenweber E, Hradetzky D (1986) New flavonoids from the exudate of *Baccharis bigelovii* (Asteraceae). Z Naturforsch C J Biosci 41:946–948

Bandoni AL, Medina JE, Rondina RVD, Coussio JD (1978) Genus *Baccharis* L. I: phytochemical analysis of a non polar fraction from *B. crispa* Sprengel. Planta Med 34:328–331

Bittencourt-Mernak MI, Santana FPR, Guerreiro MP et al (2017) Prophylactic and therapeutic treatment with the flavonone sakuranetin ameliorates LPS-induced acute lung injury. Am J Phys Lung Cell Mol Phys 312:L217–L230. https://doi.org/10.1152/ajplung.00444.2015

Bohlmann F, Knauf W, King RM, Robinson H (1979) Naturally occurring terpene derivatives. 196 new diterpene and other compounds from *Baccharis* species. Phytochemistry 18:1011–1014

Bohlmann F, Zdero C, Grenz M et al (1981a) Naturally occurring terpene derivatives. 307 five diterpenes and other constituents from nive *Baccharis* species. Phytochemistry 20:281–286. https://doi.org/10.1016/0031-9422(81)85107-2

Bohlmann F, Kramp W, Grenz M et al (1981b) Naturally occurring terpene derivatives. Part 359. diterpenes from *Baccaris* species. Phytochemistry 20:1907–1913. https://doi.org/10.1016/0031-9422(81)84033-2

Bohlmann F, Banerjee S, Jakupovic J et al (1985) Clerodane and labdane diterpenoids from *Baccharis* species. Phytochemistry 24:511–515. https://doi.org/10.1016/S0031-9422(00)80758-X

Borella JC, Duarte DP, Novaretti AAG et al (2006) Seasonal variability in the content of saponins from *Baccharis trimera* (Less.) DC (carqueja and Isolation of Flavone). Rev Bras Farmacogn 16:557–561

Cabrera J, Saavedra E, del Rosario H et al (2016) Gardenin B-induced cell death in human leukemia cell involves multiple caspases but is independent of the generation of reactive oxygen species. Chem Biol Interact 256:220–227. https://doi.org/10.1016/j.cbi.2016.07.016

Calle A, Yupanqui J, Flores Y, Almanza GR (2012) Flavonoids of *Baccharis boliviensis*. Boliv J Chem 29:158–163

Campos FR, Bressan J, Jasinski VCG et al (2016) *Baccharis* (Asteraceae): chemical constituents and biological activities. Chem Biodivers 13:1–17. https://doi.org/10.1002/cbdv.201400363

Cariddi L, Escobar F, Sabini C et al (2012) Apoptosis and mutagenicity induction by a characterized aqueous extract of *Baccharis articulata* (Lam.) Pers. (Asteraceae) on normal cells. Food Chem Toxicol 50:155–161. https://doi.org/10.1016/j.fct2011.11.002

Cestari SH, Bastos JK, Di Stasi LC (2011) Intestinal anti-inflammatory activity of *Baccharis dracunculifolia* in the trinitrobenzenesulphonic acid model of rat colitis. J Evid Based Complementary Altern Med 50:1091–1097. https://doi.org/10.1093/ecam/nep081

Chidiak S, Guada M, Buitrago D, Morales A (2007) Flavonoids isolated from *Baccharis nitida* (Ruiz et Pavon Pers). Cienc 15:361–365

Cordano GF, Munoz de la Pena A, Medina JJ (1982) Scopoletin and hispidulin in *Baccharis magellanica*. J Nat Prod 45:653. https://doi.org/10.1021/np50023a029

da Silva Filho AA, de Sousa JPB, Soares S et al (2008) Antimicrobial activity of the extract and isolated compounds from *Baccharis dracunculifolia* D.C. (Asteraceae). Z Naturforsch C 63:40–46

da Silva Filho AA, Resende DO, Fukui MJ et al (2009) In vitro antileishmanial, antiplasmodial and cytotoxic activities of phenolics and triterpenoids from *Baccharis dracunculifolia* D. C. (Asteraceae). Fitoterapia 80:478–482. https://doi.org/10.1016/j.fitote.2009.06.007

da Silva DPL, da Silva Filho AA, Polizello ACM et al (2004) Comparative evaluation of in-vitro effects of Brazilian green Propolis and *Baccharis dracunculifolia* extracts on cariogenic factors of *Streptococcus mutans*. Biol Pharm Bull 27:1834–1839

da Silva ARH, Reginato FZ, Guez CG et al (2016) Acute and sub-chonic (28 days) oral toxicity evaluation of tincture *Baccharis trimera* (Less) baker in male and female rodent animals. Regul Toxicol Pharmacol 74:170–177. https://doi.org/10.1016/j.yrtph.2015.10.024

Daily A, Wagner H, Seligmann O (1984) Hispidulin and stigmasta-7,22-dien-3-ol from *Baccharis genistelloides*. Fitoterapia 55:236–238

Davies KM, Schwinn KE (2006) Molecular biology and biotechnology of flavonoid biosynthesis. In: Andersen OM, Markham KR (eds) Flavonoids, chemistry, biochemistry and applications. CRC Taylor & Francis Group, Boca Raton, pp 143–218

Davila M, Sterner O, Hinojosa N (2013) Flavonoids from *Baccharis polycephala* Weddell. Boliv J Chem 30:137–141

de Alencar SM, de Aguiar CL, Paredes-Guzmán J, Park YK (2005) Chemical composition of *Baccharis dracunculifolia*, the botanical source of propolis from the states of São Paulo and Minas Gerais, Brazil. Cienc Rural 35:909–915

de Araujo GR, Rabelo ACS Meira JS et al (2016) *Baccharis trimera* inhibits reactive oxygem species production through PKC and down-regulation p47phox phosphorylation of NADPH oxidase in SK Hep-1 Cells. Exp Biol Med 242:333–343. https://doi.org/10.1177/1535370216672749

de Mello JCP, Petrovick PR (2000) Quality control of *Baccharis trimera* (Less.) DC. (Asteraceae) hydroalcoholic extracts. Acta Farm Bonaer 19:211–215

de Oliveira SQ, Kappel VD, Pires VS et al (2014) Antioxidant properties of phenolic compounds from *Baccharis articulata* and *B. usterii*. Nat Prod Commun 9:941–942

de Sousa JPB, da Silva Filho AA, Bueno PCP et al (2009) A validated reverse-phase HPLC analytical method for the quantification of phenolic compounds in *Baccharis dracunculifolia*. Phytochem Anal 20:24–32

de Sousa JPB, Leite MF, Jorge R et al (2011) Seasonality role on the phenolics from cultivated *Baccharis dracunculifolia*. J Evid Based Complementary Altern Med 2011:1–9. https://doi.org/10.1093/ecam/nep077

del Corral S, Cuffini SL, Cardoso SG et al (2012) Phytotoxic halimanes isolated from *Baccharis salicifolia* (Ruiz & Pad.) Pers. Phytochem Lett 5:280–283. https://doi.org/10.1016/j.phytol.2012.02.001

Dewick PM (2009) Medicinal natural products: a biosynthetic approach, 3rd edn. Wiley, New York

Escobar Z, Flores Y, Tejeda L et al (2009) Phenolic compounds from *Baccharis papillosa* subsp. *papillosa*. Boliv J Chem 26:111–117

Faine F, Rivera P, Mahu M, Castilho M (1987) Neo-clerodane diterpenoids and other constituents from *Baccharis* species. Phytochemistry 26:3281–3283. https://doi.org/10.1016/S0031-9422(00)82487-5

Faini FA, Castillo M, Torres RM (1982a) Flavonoids of *Baccharis incarum*. J Nat Prod 45:501–502. https://doi.org/10.1021/np50022a027

Faini FA, Castillo M, Torres RM (1982b) Two unusual flavonoids in *Baccharis incarum*. Bol Sol Chil Quim 27:276–279

Faini F, Hellwig F, Labbe C, Castillo M (1991) Hybridization in the genus *Baccharis*: *Baccharis linearis* x B. *macraei*. Biochem Syst Ecol 19:53–57. https://doi.org/10.1016/0305-1978(91)90113-E

Faini F, Labbe C, Coll J (1999) Seasonal changes in chemical composition of epicuticular waxes from the leaves of *Baccharis linearis*. Biochem Syst Ecol 27:673–679. https://doi.org/10.1016/S0305-1978(98)00131-8

Feresin GE, Tapia A, Gimenez A et al (2003) Constituents of the Argentinian medicinal plant *Baccharis grisebachii* and their antimicrobial activity. J Ethnopharmacol 89:73–80. https://doi.org/10.1016/S0378-8741(03)00259-9

Ferreira JVN, Grecco SS, Lago JHG et al (2015) Ultrathin films of lipids to investigate the action of a flavonoid with cell membrane models. Mater Sci Eng 48:112–117. https://doi.org/10.1016/j.msec.2014.11.061

Figueiredo-Rinhel ASG, Kabeya LM, Bueno PCP et al (2013) Inhibition of the human neutrophil oxidative metabolism by *Baccharis dracunculifolia* DC (Asteraceae) is influenced by seasonality and the ratio of caffeic acid to other phenolic compounds. J Ethnopharmacol 150:655–664. https://doi.org/10.1016/j.jep.2013.09.019

Fukuda M, Ohkoshi E, Makino M, Fujimoto Y (2006) Studies on the constituents of the leaves of *Baccharis dracunculifolia* (Asteraceae) and their cytotoxic activity. Chem Pharm Bull 54:1465–1468

Fullas F, Hussain RA, Chai HB et al (1994) Cytotoxic constituents of *Baccharis gaudichaudiana*. J Nat Prod 57:801–807. https://doi.org/10.1021/np50108a017

Gene RM, Cartana C, Adzet T et al (1996) Anti-inflammatory and analgesic activity of *Baccharis trimera*. Identification of its active constituents. Planta Med 62:232–235. https://doi.org/10.1055/s-2006-9578666

Gianello JC, Giordano OS (1984) Chemical examination of six species of the *Baccharis* genus. Rev Latinoam Quim 15:84–86

Gianello JC, Giordano OS (1987) Constituents from *Baccharis grisebachii*. An Asoc Quim Argent 75:1–3

Gianello JC, Giordano OS (1989) Chemical components from *Baccharis triangularis*. An Asoc Quim Argent 77:353–357

Gianello JC, Cifuente DA, Giordano OS, Tonn CE (1999) Bioactive flavones and terpenes from *Baccharis calliprinos* and *B. rhetinodes* (Asteraceae). Acta Farm Bonaer 18:99–102

Grecco SS, Gimenes L, Ferreira MJP et al (2010a) Triterpenoids and phenolic derivatives from *Baccharis uncinella* C.DC. (Asteraceae). Biochem Syst Ecol 38:1234–1237. https://doi.org/10.1016/j.bse.2010.12.005

Grecco SS, Reimao JQ, Tempone AG et al (2010b) Isolation of an antileishmanial flavanone from the leaves of *Baccharis retusa* DC (Asteraceae). Parasitol Res 106:1245–1248

Grecco SS, Ferreira MJP, Romoff P et al (2012a) Phenolic derivatives from *Baccharis retusa* DC. (Asteraceae). Biochem Syst Ecol 42:21–24. https://doi.org/10.1016/j.bse.2011.12.014

Grecco SS, Reimao JQ, Tempone AG et al (2012b) In vitro antileishmanial and antitrypanosomal activities of flavanones from *Baccharis retusa* DC. (Asteraceae). Exp Parasitol 130:141–145. https://doi.org/10.1016/j.exppara.2011.11.002

Grecco SS, Dorigueto AC, Landre IM et al (2014a) Structural crystalline characterization of sakuranetin – an antimicrobial flavanone from twigs of *Baccharis retusa* (Asteraceae). Molecules 19:7528–7542. https://doi.org/10.3390/molecules19067528

Grecco SS, Felix MJP, Lago JHG et al (2014b) Anti-trypanosomal phenolic derivatives from *Baccharis uncinella*. Nat Prod Commun 9:171–173

Guimaraes NSS, Melo JC, Paiva JS et al (2012) *Baccharis dracunculifolia*, the main source of green propolis, exhibits potent antioxidant activity and prevents oxidative mitochondrial damage. Food Chem Toxicol 50:1091–1097. https://doi.org/10.1016/j.fct.2011.11.014

Guo Y, Li Y, Xu J et al (2007) Clerodane diterpenoids and flavonoids with NGF-potentiating activity from the aerial parts of *Baccharis gaudichaudiana*. Chem Pharm Bull 55:1532–1534

He K (1995) Phytochemical investigations of medicinal plants from Chile and the Fiji islands (*Baccharis linearis*, *Aristotelia chilensis*, *Dysoxylum lenticellare*). The University of Arizona, 182 pp

He K, Montenegro G, Hoffmann JJ, Timmermann BN (1996) Diterpenoids from *Baccharis linearis*. Phytochemistry 41:1123–1127. https://doi.org/10.1016/0031-9422(95)00780-6

Hennig L, Garcia GM, Giannis A, Bussmann RW (2011) New constituents of *Baccharis genistelloides* (Lam.) Pers. ARKIVOC 6:74–81. https://doi.org/10.3998/ark.5550190.0012.607

Herrera JC, Romero AJR, Crescente OE et al (1996) Analysis of 5-hydroxy-7-methoxyflavones by normal-phase high-performance liquid chromatography. J Chromatogr A 740:201–206. https://doi.org/10.1016/0021-9673(96)00108-2

Herz W, PIlotti AM, Soderholm AC et al (1977) New ent-clerodane-type diterpenoid from *Baccharis trimera*. J Organomet Chem 42:3913–3917. https://doi.org/10.1021/jo00444a026

Jakupovic J, Eid F, King RM (1986) Further ingredients of *Baccharis trinervis*. Pharmazie 41:157–158

Jakupovic J, Schuster A, Ganzer U et al (1990) Sesqui- and Diterpenes from *Baccharis* species. Phytochemistry 29(7):2217–2222. https://doi.org/10.1016/0031-9422(90)83041-X

Jaramillo-Garcia V, Trindade C, Lima E et al (2018) Chemical characterization and cytotoxic, genotoxic, and mutagenic properties of *Baccharis trinervis* (lam, Persoon) from Colombia and Brazil. J Ethnopharmacol 213:210–220. https://doi.org/10.1016/j.jep.2017.10.027

Joshi SB, Haider IS, Pelletier WS (1997) Flavonoids from *Baccharis halimifolia*, *Monarda didyma*, and *Gnaphalium dioicum*. J Indian Chem Soc 74:874–876

Kakehashu A, Ishii N, Fujioka M et al (2016) Ethanol-extracted Brazilian propolis exerts protective effects on tumorigenesis in wistar hannover rats. PLoS One 11:e0158654/1–e0158654/15. https://doi.org/10.1371/journal.pone.0158654

Kumazawa S, Yoneda M, Shibata I et al (2003) Direct evidence for the plant origin of Brazilian propolis by the observation of honeybee behavior and phytochemical analysis. Chem Pharm Bull 51:740–742. https://doi.org/10.1248/cpb.51.740
Kuroyanagi M, Fujita K, Kazaoka M et al (1985) Studies on the constituents of *Baccharis genistelloides*. Chem Pharm Bull 33:5075–5078. https://doi.org/10.1248/cpd.33.5075
Labbe C, Rovirosa J, Faini F et al (1986) Secondary metabolites from Chilean *Baccharis* species. J Nat Prod 49:517–518. https://doi.org/10.1021/np50045a025
Labbé C, Faini F, Castillo M (1990) Diterpenoids from Chilean *Baccharis* species. Phytochemistry 29:324–325
Lemos M, de Barros MP, Sousa JBP (2007) *Baccharis dracunculifolia*, the main botanical source of Brazilian green propolis, displays antiulcer activity. J Pharm Pharmacol 59: 603–608. https://doi.org/10.1211/jpp.59.4.0017
Liu YL, Timmermann BN, Hoffmann JJ et al (1993) A flavonol triglycoside from *Baccharis thesioides*. Phytochemistry 33:1549–1551. https://doi.org/10.1016/0031-9422(93)85134-D
Mejia-Giraldo JC, Sanchez-Zapata AM, Puertas-Mejia MA et al (2016) Photoprotective potential of *Baccharis antioquensis* (Asteraceae) as natural sunscreen. Photochem Photobiol 92:742–752
Menezes APS, da Silva J, Fisher C et al (2016) Chemical and toxicological effects of medicinal *Baccharis trimera* extract from coal burning area. Chemosphere 146:396–404. https://doi.org/10.1016/j.Chemosphere.2015.12.02
Mesquita AAL, Correa DB, de Padua AP et al (1985) Flavonoids from four Compositae species. Phytochemistry 25:1255–1256. https://doi.org/10.1016/S0031-9422(00)81599-X
Midorikawa K, Banskota AH, Tezuka Y et al (2003) Buds of *Baccharis dracunculifolia*: potente source of biologically active e caffeoyquinic acids and labdane-type diterpenes of Brazilian propolis. J Pharm Soc Jpn 20:187–194
Missima F, da Silva Filho AA, Nunes GA et al (2007) Effect of *Baccharis dracunculifolia* D.C. (Asteraceae) extracts and its isolated compounds on macrophage activation. J Pharm Pharmacol 59:463–468
Mollinedo P, Salcedo OL, Vila JL et al (2001) Evaluation of the antioxidant capacity of three Bolivian plant species. Boliv J Chem 18:59–64
Montes GM, Wikomirski FT, Valenzuela RL, Neira MR (1971) Alkaloids of *Baccharis linearis*. Rev R Acad de Cienc Exactas, Fis Nat Madr 65:499–511
Morales Mendez A, Nunez O, Rosquete C, Montilla A (1984) Flavones from *Baccharis decussata* (Klatt) Hieron. An Quim, Serie C: Quimica Organica y Bioquimica 80:98–99
Moreira EA, Keller CC, Krambeck R, Miguel OG (1975) Phytochemical analysis of *Baccharis maritima*. Preliminary chemical investigation, and identification of polyphenolic substances. Phytochem Anal 43:3–17
Moreira FPM, Branco A, Pizzolatti MG et al (2003a) Acid triterpenes and flavonoids from *Baccharis ligustrina* (Asteraceae). Biochem Syst Ecol 31:319–321. https://doi.org/10.1016/S0305-1978(02)00149-7
Moreira FPM, Voutinho V, Pimentel Montanher AB et al (2003b) Flavonoids and triterpenes from *Baccharis pseudotenuifolia* – bioactivity on *Artemia salina*. Quim Nova 26:309–311. https://doi.org/10.1590/S0100-40422003000300004
Nagatani Y, Warashina T, Noro T (2001) Studies on the constituents from the aerial part of *Baccharis dracunculifolia* DC. Chem Pharm Bull 49:1388–1394. https://doi.org/10.1248/cpd.49.1388
Nakasugi T (1990) Anti-mutagen agents. Japan. Kokai Tokkyo Koho JP 11180867 a 19990706
Nakasugi T, Komai K (1998) Antimutagens in the Brazilian folk medicinal plant carqueja (*Baccharis trimera Less*.). J Agric Food Chem 46:2560–2564. https://doi.org/10.1021/JF9711045
Nogueira Sobrinho AC, de Souza EB, Rocha MFG et al (2016) Chemical composition, antioxidant, antifungal and hemolytic activies of essential oil from *Baccharis trivervis* (Lam.) Pers. (Asteraceae). Ind Crop Prod 84:108–115. https://doi.org/10.1016/j.indcrop.2016.01.051
Nuño G, Zampini IC, Ordonez RM et al (2012) Antioxidant/antibacterial activities of a topical phytopharmaceutical formulation containing a standardized extract of *Baccharis incarum*, an extremophile plant species from Argentine Puna. Phytother Res 26:1759–1767. https://doi.org/10.1002/ptr.4633

Padua BC, Rossoni JVJ, Magalhaes CLB et al (2014) Protective effect of *Baccharis trimera* extract on acute hepatic injury in a modelo of inflammation induced by acetaminophen. Mediat Inflamm 196598:1–15. https://doi.org/10.1155/2014/196598

Palacios P, Gutkind G, Rondina RV et al (1983) Genus *Baccharis*. II. Antimicrobial activity of *B. crispa* and *B. notosergila*. Planta Med 49:128.

Park YK, Paredes-Guzman JF, Aguiar CL et al (2004) Chemical constituents in *Baccharis dracunculifolia* as the main botanical origin of southeastern Brazilian propolis. J Agric Food Chem 52:1100–1103

Park YK, Fukuda I, Ashida H et al (2005) Suppressive effects of ethanolic extracts from propolis and its main botanical origin on dioxin toxicity. J Agric Food Chem 53:10306–10309. https://doi.org/10.1021/jf058111a

Parodi FJ, Fischer NH (1988) Guaianolides from *Baccharis salicina*. Phytochemistry 27:2987–2988. https://doi.org/10.1016/0031-9422(88)80705-2

Passero LFD, Bonfim-Melo A, Corbett CEP et al (2011) Anti-leishmanial effects of purified compounds from aerial parts of *Baccharis uncinella* C. DC (Asteraceae). Parasitol Res 108:529–536

Paula JT, Sousa IMO, Foglio MA, Cabral FA (2017) Selective fractionation of supercritical extracts from leaves of *Baccharis dracunculifolia*. J Supercrit Fluids 127:62–70. https://doi.org/10.1016/j.supflu.2017.03.032

Piantino CR, Aquino FWB, Follegatti-Romero LA, Cabral FA (2008) Supercritical CO_2 extraction of phenolic compounds from *Baccharis dracunculifolia*. J Supercrit Fluids 47:209–214. https://doi.org/10.1016/j.supflu.2008.07.012

Pizzolatti MG, Verdi LG, Brighente IMC et al (2006) Anticoagulant effect and constituents of *Baccharis illinita*. Nat Prod Commun 1:37–42

Quijano L, Rios T, Fronczek FR, Fischer NH (1998) The molecular structure of maniladiol from *Baccharis salicina*. Phytochemistry 49:2065–2068. https://doi.org/10.1016/S0031-9422(98)00363-X

Rabelo ACS, de Araujo GR, Lucio KP et al (2017) Aqueous extract of *Baccharis trimera* improves redox status and decreases the severity of alcoholic hepatotoxicity. Rev Bras Farmacogn 27:729–738. https://doi.org/10.1016/j.bjp.2017.09.003

Rahalison L, Benathan M, Monod M et al (1995) Antifungal principles of *Baccharis pedunculata*. Planta Med 61:360–362. https://doi.org/10.1055/s-2006-958101

Rendon W, Vila JL (1995) Phytochemical study of *Baccharis trimera*. Boliv J Chem 12:13–15

Resende FA, Alves JM, Munari CC et al (2007) Inhibition of doxorubicin-induced mutagenicity by *Baccharis dracunculifolia*. Mutat Res 634:112–118

Rezende TP, Correa JOA, Aarestrup BJV et al (2014) Protective effects of *Baccharis dracunculifolia* leaves extract against carbon tetrachloride- and acetaminophen-induced hepatotoxicity in experimental animals. Molecules 19:9257–9272. https://doi.org/10.3390/molecules19079257

Rivera FA, Faini F, Castilho M (1988) 15α-hydroxy-β-amyrin and patogonic acid from *Baccharis magellanica* and *Baccharis paragonica*. J Nat Prod 51:155–157. https://doi.org/10.1021/np50055a026

Rodriguez MV, Martinez ML, Cortadi A et al (2012) Quality control of herbal medicines with spectrophotometry and chemometric techniques – application to *Baccharis* L. species belonging to sect – Caulopterae DC. (Asteraceae). In: Macro to nano spectroscopy. IntechOpen, Jamal Uddin, pp 399–420

Rojas J, Morales A (2000) Study of the chemical components of *Baccharis decussata* (K) Hieron. Ciencia 8:251–256

Saad JR, Pestchanker MJ, Giordano OS (1987) Furanditerpenes from *Baccharis thymifolia*. Phytochemistry 26:3033–3035. https://doi.org/10.1016/S0031-9422(00)84587-2

Saad JR, Davicino JG, Giordano OS (1988) A Diterpene and flavonoid of *Baccharis flabellata*. Phytochemistry 27:1884–1887. https://doi.org/10.1016/0031-9422(88)80471-0

Sabir SM, Athayde ML, Boligon AA, Rocha JBT (2017) Antioxidant activities and phenolic profile of *Baccharis* a commonly used medicinal plant from Brazil. S Afr J Bot 113:318–323. https://doi.org/10.1016/j.saj.2017.09.010

Sakoda CPP, Prado CM, de Toledo AC et al (2016) Sakuranetin reverses vascular peribronchial and lung parenchyma remodeling in a murine model of chronic allergic pulmonary inflammation. Acta Histochem 118:615–624. https://doi.org/10.1016/j/acthis.2016.07.001

Salcedo Ortiz L, Sterner O, Almanza Vega GR (2001) Phytochemical study of *Baccharis latifolia*. Boliv J Chem 18:43–46

Salcedo L, Pillco A, Rodrigo G et al (2003) Isolation of flavonoids and study of the toxic and antibacterial activity of *Baccharis latifolia* extracts. Boliv J Chem 20:43–48

San Martin A, Rovirosa J, Castillo M (1982) Diterpenes from *Baccharis tola*. Part II. Bol Soc Chil Quim 27:252–254

San Martin A, Rovirosa J, Castillo M (1983) Diterpenoids from *Baccharis tola*. Phytochemistry 22:1461–1463. https://doi.org/10.1016/S0031-9422(00)84036-4

San Martin AJ, Villanueva E, Cruz AT et al (2012) Phytochemical and preliminary sprectroscopic study of five medicinal plants of Carmen Pampa (Coroico) Bolivia. Boliv J Chem 29:121–130

Sartor T, Xavier VB, Falcao MA et al (2013) Seasonal changes in phenolic compounds and in the biological activities of *Baccharis dentata* (Vell.) G.M. Barroso. Ind Crop Prod 51:355–359. https://doi.org/10.1016/j.indcrop.2013.09.018

Schenkel EP, Sobottka AM, Lankhorst PP et al (1997) An unusual diterpene and other constituents from *Baccharis ochracea*. Phytochemistry 44:755–757. https://doi.org/10.1016/S0031-9422(96)00565-1

Sharp H, Bartholomew B, Bright C et al (2000) 6-Oxygenated flavones from *Baccharis trinervis* (Asteraceae). Biochem Syst Ecol 29:105–107. https://doi.org/10.1016/S0305-1978(00)00019-3

Silva Filho AA, Pires PCB, Gregorio LE et al (2004) In vitro trypanocidal activity evaluation of crude extract and isolated compounds from *Baccharis dracunculifolia* D.C. (Asteraceae). J Pharm Pharmacol 56:1195–1199. https://doi.org/10.1211/0022357044067

Silva M, Mundaca JM, Sammes PG (1971) Flavonoid and triterpene constituents of *Baccharis rhomboialis*. Phytochemistry 10:1942–1943. https://doi.org/10.1016/S0031-9422(00)86469-9

Silva GAB, Henriques A, Alice CB et al (1985) Methoxyflavones from *Baccharis* patens (Asteraceae). J Nat Prod 48:861. https://doi.org/10.1021/np50041a041

Silva FG, Januario AH, Pinto JEBP et al (2006) Flavonoid content in nature and cultivated populations of "carqueja" [*Baccharis trimera* (Less.) DC.] Harvested in dry and humid seasons. Rev Bras Plant Med 8:19–25

Simirgiotis MJ, Garcia M, Sosa ME et al (2003) Na ent-kaurene derivative from aerial parts of *Baccharis rufescens*. J Argent Chem Soc 91:109–116

Simirgiotis MJ, Quispe C, Borquez J et al (2016) High resolution metabolite fingerprinting of the resin of *Baccharis tola* Phill. from the Atacama desert and its antioxidant capacities. Ind Crop Prod 94:368–375. https://doi.org/10.1016/j.indcrop.2016.08.037

Simões-Pires CA, Queiroz EF, Henriques AT, Hostettmann K (2005) Isolation and on-line identification of antioxidant compounds from three *Baccharis* species by HPLC-UV-MS/MS with post-column derivatisation. Phytochem Anal 16:307–314

Soicke H, Leng-Eschlow E (1987) Characterization of flavonoids from *Baccharis trimera* and their antihepatotoxic properties. Planta Med 53:37–39

Suttisri R, Kighorn AD, Wright AD, Sticher O (1994) Neo-clerodane diterpenoids and other constituents from *Baccharis genistelloides*. Phytochemistry 35:443–446. https://doi.org/10.1016/S0031-9422(00)94778-2

Taguchi L, Pinheiro NM, Olivo CR et al (2015a) A flavanone from *Baccharis retusa* (Asteraceae) prevents elastase-induced emphysema in mice by regulating nf-κb, oxidative stress and metalloproteinases. Respir Res 16:1–15. https://doi.org/10.1186/s12931-015-0233-3

Taguchi L, Pinheiro NM, Olivo CR et al (2015b) Erratum: a flavanone from *Baccharis retusa* (Asteraceae) prevents elastase-induced emphysema in mice by regulating NF-κB, oxidative stress and metalloproteinases. Respir Res 16:113. https://doi.org/10.1186/s12931-015-0258-7

Tapia A, Rodriguez J, Theoduloz C et al (2004) Free radical scavengers and antioxidants from *Baccharis grisebachii*. J Ethnopharmacol 95:155–161

Tarqui ST, Segura YF, Veja GRA (2012) Polyoxygenated flavonoids from *Baccharis pentlandii*. Boliv J Chem 29:10–14

Toledo AC, Sakoda CPP, Perini A et al (2013) Flavonone treatment reverses airway inflammation and remodelling in an asthma murine model. Br J Pharmacol 168:1736–1749. https://doi.org/10.1111/bph.12062

Tonn CE, Rossomando PC, Giordano OS (1982) Batudioic acid and flavonoid from *Baccharis tucumanensis*. Phytochemistry 21:2599–2600. https://doi.org/10.1016/0031-9422(82)85268-0

Torres LMB, Gamberini MT, Roque NF et al (2000) Diterpene from *Baccharis trimera* with a relaxant effect on rat vascular smooth muscle. Phytochemistry 55:617–619. https://doi.org/10.1016/S0031-9422(00)00223-5

Toyama DO, Gaeta HH, Terashima de Pinho MV et al (2014) An evaluation of 3-rhamnosylquercetin, a glycosylated form of quercetin, against the myotoxic and edematogenic effects of sPLA2 from *Crotalus durissus terrificus*. Biomed Res Int 2014:1–11. https://doi.org/10.1155/2014/341270

Ueno AK, Barcello AF, Grecco SS et al (2018) Sesquiterpenes, diterpenes, alkenyl p-coumarates, and flavonoid from the aerial parts of *Baccharis retusa* (Asteraceae). Biochem Syst Ecol 78:39–42. https://doi.org/10.1016/jbase.2018.03.013

Verdi LG, Brighente IMC, Schripsema J et al (2004) Kaurene diterpenes and flavonoids from *Baccharis illinita* flowers. Biochem Syst Ecol 32:837–840. https://doi.org/10.1016/j.bse.2002.11.008

Vidari G, Vita FP, Zarzuelo A et al (2003) Antiulcer and antidiarrhoeic effect of *Baccharis teindalensis*. Pharm Biol 41:405–411. https://doi.org/10.1076/phbi.41.6.405.17832

Visintini JMF, Redko F, Muschietti L et al (2013) In vitro antiviral activity of plant extracts from Asteraceae medicinal plants. Virol J 10:1–10. https://doi.org/10.1186/1743-422x-10-245

Wagner H, Iyengar MA, Herz W (1972) Flavonol 3-glucosides in *Baccharis angustifolia* and *Berlandiera pumila*. Phytochemistry 11:444. https://doi.org/10.1016/S0031-9422(00)90045-1

Wagner H, Seitz R, Lotter H, Herz W (1978) New Furanoid Ent-clerodanes from *Baccharis tricuneata*. J Organomet Chem 43:3339–3345. https://doi.org/10.1021/jo00411a017

Warning U, Bohlmann F, Sanchez VH et al (1986) New constituents of *Baccharis salicifolia*. Rev Latinoam Quim 17:199–200

Weimann C, Goransson U, Pongprayoon-Claeson U et al (2002) Spasmolytic effects of *Baccharis conferta* and some of its constituents. J Pharm Pharmacol 54:99–104

Wollenweber E, Schober I, Dostal P et al (1986) Flavonoids and terpenoids from the exudates of some *Baccharis* species. J Biosci 41:87–93

Wollenweber E, Dorr M, Fritz H et al (1997) Exudate flavonoids in Asteraceae from Arizona, California, and Mexico. Z Naturforsch C J Biosc 52:301–307

Wollenweber E, Valant-Vetschera KM, Fernandes GW (2006) Chemodiversity of exudate flavonoids in *Baccharis concinna* and three further South-American *Baccharis* species. Nat Prod Commun 1:627–632

Zalewski CA, Passero LFD, Melo ASRB et al (2011) Evaluation of anti-inflammatory activity of derivatives from aerial parts of *Baccharis uncinella*. Pharm Biol 49:602–607. https://doi.org/10.3109/13880209.2010.537828

Zamorano R, Aguirre ME, Munoz de la Pena A et al (1987) Flavonoids from *Baccharis concava* Pers. Bol Soc Chil Quim 32:101–103

Zampini IC, Isla MI, Schmeda-Hirschmann G (2009) Antimicrobial and antioxidant compounds from the infusion and methanolic extract of *Baccharis incarum* (Wedd.) Perkins. J Chil Chem Soc 54:477–481. https://doi.org/10.4067/S0717-97072009000400035

Zdero C, Bohlmann F, King RM, Robinson H (1986) Diterpene glycosides and other constituents from Argentinian *Baccharis* species. Phytochemistry 25:2841–2855. https://doi.org/10.1016/S0031-9422(00)83754-1

Zdero C, Bohlmann F, Niemeyer HM (1991) An unusual dimeric sesquiterpene and other constituents from Chilean *Baccharis* species. Phytochemistry 30:1597–1601. https://doi.org/10.1016/0031/9422(91)86215-E