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Chemical characterization and antimicrobial activity of *Blumenbachia insignis* (Loasaceae) native to South America

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Abstract

Background: *Blumenbachia insignis* is a plant native to Brazil, Uruguay, and Argentina. It is used as an ornamental plant for its flowers, but also, in popular medicine, the stems and leaves are used as antirheumatic agents. Detailed studies on the differential chemical composition of their organs were carried out to establish a relationship with their biological activity and ethnomedicinal uses and the compounds present.

Results: The presence of phenolic compounds, flavonoids, and triterpenoid saponins was detected in the extracts of the different organs of *Blumenbachia insignis*, those of the flower being the ones that had the highest concentration of these families of compounds, and also the highest antioxidant and antimicrobial activity. Volatile compounds were identified using gas chromatography coupled to mass spectrometry (GC–MS) in all the extracts. Some of them possess recognized antimicrobial and antioxidant activity among others. On the other hand, the roots showed an important presence of monoterpenes, not so common for these organs.

Conclusions: These characteristics could be useful to prevent various oxidative stress processes and against pathogenic bacteria.

Keywords: *Blumenbachia insignis*, Loasaceae, Polyphenol, Flavonoid, GC–MS

Background

In Argentina, the use of native and exotic plants in popular medicine is frequent, and their ethnopharmaceutical uses are influenced by pre-Hispanic and colonial traditions, depending on the region of analysis. In ethnomedicine, *Blumenbachia insignis* is used as an antirheumatic, analgesic, and anti-inflammatory agent (Vitto 1997; Barboza et al. 2009). This species presents only taxonomic studies and recent studies on pollination (Siriani-Oliveira et al. 2018) but it is practically unknown from the phytochemical point of view since the compounds with the biological activity present in each of its organs have not been characterized.

Inflammation is a mechanism for the protection of tissues and is the first reaction of the immune system against pathogens or other harmful stimuli to restore homeostasis in the injured tissues. Macrophages play an important role in the elimination of pathogens by employing the production of reactive oxygen species (ROS) (Hirayama et al. 2017). These free radicals have a dual role in the body, with both beneficial and harmful effects. However, the overproduction of these highly reactive species can damage important biological macromolecules such as deoxyribonucleic acid (DNA), proteins, and membrane lipids (Aikens and Dix 1991; Halliwell and Gutteridge 2015). These facts make inflammation to be considered responsible for the generation of

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cancer development precursors. In addition, many studies suggest that chronic inflammation plays an important role in a wide variety of age-related diseases such as diabetes, cardiovascular and autoimmune diseases (Chung et al. 2019). Anti-inflammatory activity in the carrageenan-induced edema test, saponins isolated from several plant sources, have shown an inhibition of inflammation, suggesting that the anti-inflammatory activity of these saponins could be related to an anticomplementary action through the classic route of inflammation (Gonzalez-Madariaga et al. 2020). Recently, there has been an increased interest in the search for natural antioxidants such as polyphenols, present in medicinal plants and in many foods of vegetable origin. The antioxidant activity of natural compounds has been measured predominantly through various spectrophotometric assays that imply the scavenging of stable free radicals such as those derived from 1,1-diphenyl-2-picrylhydrazyl (DPPH) (Fangio et al. 2019). Several studies confirm that the antioxidant action of phytochemical products is due to their content in phenolic compounds such as flavonoids and phenolic acids. Furthermore, phenolic compounds exhibit antimicrobial activity against clinically important microorganisms and other pathogens of interest such as *Paenibacillus larvae*, the pathogen of the honey bees (*Apis mellifera* L). Terpenoids are also beneficial for human beings; many anticancer and antibiotic activities were described (Guimarães et al. 2019; Huang et al. 2012).

Antimicrobial extracts of natural origin are an alternative in growing development due to the loss of efficacy of traditional antimicrobials, related to the resistance acquired by pathogens or when the use of antibiotics is prohibited or limited as in the beekeeping industry. (Fangio et al. 2019).

Although the aspects related to the habitat, ecology, morphology, and systematics of *B. insignis* were reported (Ackermann and Weigend 2006), to the best of our knowledge, the phytochemical and pharmacological aspects are completely unknown. Therein, we here present the chemical characterization of the different parts of *B. insignis* from the southeast of the province of Buenos Aires, one of the first complete report of a species belonging to Loasaceae family.

Methods

Plant material

Rock nettle *B. insignis* belongs to the Loasaceae family (order Cornales), popularly known as "electric shock plant" or *amor seco* in the southern hemisphere, widely distributed in its native region including Brazil, Uruguay, and Argentina. The genera *Blumenbachia* (11 spp.) (Acuña Castillo et al. 2019) is a morphologically quite homogeneous group for vegetative characters, with complex floral morphology and function (Henning et al. 2015). Adult and complete specimens of *B. insignis* were identified and collected from General Madariaga. Province of Buenos Aires (37° 06′ 67″ S and 56° 98′ 33″ W) and harvested in October 2018 (Additional file 1: Table S1). The taxonomic identification of the plant was confirmed by Ing. Agr. Cardinali at the Centre of Plant Taxonomy, National University of Mar del Plata (Argentina). All the parts of the plant material, such as flower, fruit, leaf, stem, and root, were analyzed separately. Sampled plant material with its geographic origin and the herbarium voucher are given in the Appendix.

Preparation of the extracts

Dried flowers, fruits, leaves, stems, and roots (3 g each) were extracted with 50 mL ethanol 50% (v/v) for 24 h at room temperature and then filtered through a paper filter to remove insoluble residuals. The solvent was evaporated under vacuum using the rotary evaporator Büchi Rotary evaporator RII (Germany) and the extracts were stored at 4 °C for further analysis.

The preparation of the extract for gas chromatography–mass spectroscopic (GC–MS) analysis was carried out by assisted extraction in an ultrasonic bath at 25 °C, using sequentially n-hexane, ethyl acetate, and methanol as solvent. Briefly, 10 g of powdered material was soaked in 25 mL of hexane, sonicated for 30 min, and filtered. Subsequently, the residue was treated in the same way with ethyl acetate and with methanol. The three extracts were dried using a rotary evaporator and redissolved using ethyl acetate that showed redissolution capacity for all residues, and the etile acetate fractions were combined for analysis by GC–MS.

Total phenolic content

The total polyphenols content of the samples was determined according to the Folin–Ciocalteu colorimetric method (Fangio et al. 2019). The resulting absorbance was measured at 765 nm. Gallic acid solutions (0–100 µg/mL) were used to perform the calibration curve. Total polyphenols contents were expressed as mg of gallic acid equivalents (GAE) per gram of extracts. The values are presented as the mean of analyzes performed in triplicate ± standard deviation.

Total flavonoid content

Flavonoid content was determined by the method of Woisky and Salatino 1998 with some modifications. The absorbance was measured at 420 nm. Quercetin solutions between 2.5 and 25 µg/mL were used to construct the calibration curve. The content of total flavonoids was calculated as mg equivalents of quercetin (QE)/g of

extract. The values are presented as the mean of the analysis carried out in triplicate ± standard deviation.

Total saponin content

A qualitative analysis was performed. Quantification of total saponin content was carried out using oleanolic acid as a reference. The standard curve was made with 0.00, 0.25, 0.5, 0.75, 1.00, and 1.25 mL of oleanolic acid. The absorbance was read at 530 nm. The results were reported as mg saponins/g extract (Le et al. 2018). The values are presented as the mean of the analysis carried out in triplicate ± standard deviation.

Antioxidant activity

The antioxidant activity of plant extracts was determined according to Fangio et al. 2019 with slight modifications using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay. For each extract and solution of the synthetic antioxidant 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox), an aliquot was added to an ethanolic solution of 60 µM DPPH. Absorbance measurements were read at 517 nm at different times. A sample containing the same amount of ethanol and DPPH solution was taken as the blank control. The results were expressed as µmol Trolox equivalent antioxidant capacity (TEAC) per gram.

Antimicrobial activity

The minimum inhibitory concentration (MIC) of the plant extracts was evaluated by the microdilution test according to the Clinical and Laboratory Standards Institute (CLSI, 2015) (Weinstein and Patel 2018). Extracts were filtered through membranes of 0.22 µm (Titan syringe filters; Sri Scientific Resources Inc., USA) and added to the culture medium to achieve different final concentrations. Bacterial suspensions of the strains *Escherichia coli* ATCC 25,922 and *Staphylococcus aureus* ATCC 25,923 (10^5–10^6 CFU/mL) were added to the wells with Mueller–Hinton Broth, while a suspension of *Paenibacillus larvae* (ERIC I genotype) was added to Mueller–Hinton, yeast extract, glucose and sodium pyruvate broth (Fangio et al. 2019). All microtiter plates (with positive and negative controls) were incubated at 35 ± 0.5 °C for 24–48 h according to each strain. The MIC was determined as the lowest concentration inhibiting the visible growth of each strain (Kowalska-Krochmal and Dudek-Wicher 2021). The minimum bactericidal concentration (MBC) was determined by subculturing the broth dilutions from the microdilution test. The broth dilutions that inhibited the growth of the bacterial organism were streaked onto Mueller–Hinton agar or Mueller–Hinton, yeast extract, glucose, and sodium pyruvate agar and incubated for 24 to 48 h, according to each strain. The MBC was determined as the lowest dilution of antimicrobial that prevents the growth of the organism on the agar plate (Ferreira et al. 2018).

GC–MS analysis

Samples were analyzed using a Shimadzu GCMS-QP2100ULTRA-AOC20i with a column of 0.25 mm, 30 m, and 0.1 µm phase thickness Zebron ZB-5MS. Samples were injected at pulsed splitless mode, and the injection volume was 2 mL. The interface and the ionization source were kept at 300 °C and 230 °C, respectively. Helium chromatographic grade (99.9999%) was used as the carrier gas with a constant linear velocity of 52.1 cm/sec. The oven temperature program started at 50 °C, where it was held for 2 min and then increased to 300 °C at 15 °C/min where it was held for 4 min. Electron impact ionization (EI) was used at 70 eV in a full scan. The identification of compounds was achieved by analyzing the retention indexes (relative to C8–C24 *n*-alkanes) and the mass spectra were also matched to those of standards available in the National Institute of Standards and Technology (NIST) 05 and Wiley 08 mass spectrum libraries. Retention time (RT) is reported in Table 3 in order to simplify comparisons. The relative percentage contribution as a function of concentration (peak area %) of each compound was calculated from the chromatograms by a computerized integration assuming all the response factors were 1. Analyses were carried out in triplicate.

Statistical analysis

Statistical analysis was carried out using analysis of variance (ANOVA) with post hoc Tukey's honestly significant difference (HSD) test. All experiments were performed in triplicate. Results were presented as a value ± standard deviation. Significant levels were defined at $p < 0.05$. All the analyses were carried out by using SPSS 15.0 (SPSS Inc., Chicago, Ill., USA) for Windows.

Results

Total phenolic content

The total phenolic content in *B. insignis* was determined in extracts from flowers, fruits, leaves, roots, and stems (Table 1). The contents vary widely, ranging from 12.8 to 85.2 mg GAE/g extract. Flower extract presents a higher content of polyphenols ($p < 0.05$) with values of 85.2 mg GAE/g, while leaf extract presents 30.1 mg GAE/g and root extract shows 24.1 mg GAE/g. The samples obtained from fruit show the content of polyphenols of 12.8 mg GAE/g, while stem extract shows values of 15.2 mg GAE/g.

Table 1 Total phenolic content, total flavonoids content, saponins content, and antioxidant activity of the hydro-alcoholic extracts of the different organs of *B. insignis* plant

	Total phenolic content (mg GAE/g)	Total flavonoid content (mg QE/g)	Total saponin content (mg saponin/g)	TEAC (μmol/g)
Flower extract	85.2 ± 7.7 [a]	61.9 ± 3.1 [a]	0.511 ± 0.018 [a]	69.1 ± 4.2 [a]
Fruit extract	12.8 ± 1.3 [b]	4.3 ± 0.4 [b]	0.578 ± 0.020 [b]	23.4 ± 16.5 [b]
Leaf extract	30.1 ± 5.3 [c]	21.3 ± 0.3 [c]	0.595 ± 0.005 [b]	27.3 ± 1.4 [b]
Root extract	24.1 ± 1.6 [b,c]	3.2 ± 0.1 [b,d]	0.841 ± 0.008 [c]	7.9 ± 0.2 [b]
Stem extract	15.2 ± 1.3 [b]	2 ± 1.3 [d]	0.108 ± 0.005 [d]	25.9 ± 1.0 [b]

Values not sharing a common superscript letter in the same column were significantly different (Tukey's HSD test, $p < 0.05$)

Values of the same parameter (vertical columns) with different superscripts differs significantly ($P < 0.05$)

Total flavonoids content

The total flavonoids content in *B. insignis* was determined in extracts from flowers, fruits, leaves, roots, and stems (Table 1). Values of total flavonoids content in the analyses of B. insignis extracts ranged from 2 to 61.9 mg QE/g (Table 1). Flower and leaf extracts present a higher content of flavonoids, being flower extracts the part of the plant with the highest significant ($p < 0.05$) values (61.9 mg QE/g). The samples obtained from fruit (4.3 mg QE/g), root (3.2 mg QE/g), and stem (2 mg QE/g) showed slight differences in their total flavonoid content.

Saponin content

The result of saponin content in the different extracts of *B. insignis* is presented in Table 1. The highest significant ($p < 0.05$) content of saponins in *B. insignis* was found in roots (0.841 mg saponin/g), while stem extract (0.108 mg saponin/g) presented a lower content of saponins.

Antioxidant activity

The DPPH radical scavenging activities of different extracts of *B. insignis* are shown in Table 1. The TEAC value compares the DPPH radical scavenging capacity of the extracts with the synthetic antioxidant Trolox, a water-soluble analog of vitamin E. All extracts showed DPPH radical scavenging activities, with a range between 69.1 and 7.9 μmol TEAC/g extracts. Flower extract exhibits the highest significant ($p < 0.05$) scavenging activity (69.1 μmol TEAC/g). Extracts of fruit (23.4 μmol TEAC/g), leaf (27.3 μmol TEAC/g), stem (25.9 μmol TEAC/g), and root (7.9 μmol TEAC/g) show lower values.

Antimicrobial activity of different plant parts

The microdilution broth method was used to evaluate the antimicrobial activity of the different parts of *B. insignis* (Table 2). Flowers and leaves were the extracts that showed antimicrobial activity against all the strains tested, with values of MIC of 0.45 mg/mL for flower and 0.65 mg/mL for leaves for *E. coli,* and 1.3 mg/mL for leaves in the case of *S. aureus* and *P. larvae* (Table 2). Fruits (0.75 mg/mL) and roots extract (0.95 mg/mL) showed antimicrobial activity against *E. coli* and *S. aureus*, while stem showed activity against *P. larvae*. The extracts' effects were more pronounced against the Gram-negative *E. coli*, while *S. aureus* and *P.*

Table 2 Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of different *B. insignis* extracts for different bacteria

Plant extract	*E. coli*		*S. aureus*		*P. larvae*	
	ATCC 25,922		ATCC 25,923		ERIC I genotype	
	MIC	MBC	MIC	MBC	MIC	MBC
	mg/mL	mg/mL	mg/mL	mg/mL	mg/mL	mg/mL
Flower	0.45	> 0.45	0.45	> 0.45	0.45	> 0.45
Fruit	0.75	> 0.75	0.75	> 0.75	> 0.75	> 0.75
Leaf	0.65	1.3	1.3	1.3	1.3	1.3
Root	0.95	0.95	0.95	1.9	> 1.9	> 1.9
Stem	> 1.5	> 1.5	> 1.5	> 1.5	1.5	> 1.5

The sign > indicates colony development after inoculation with the specific MIC; therefore, the MBC is reported as "greater than" the concentration value in each case

larvae (both Gram-positive) remain the most resistant bacteria.

Gas chromatography–mass spectroscopic analysis of the different organs of *B. insignis*

Compounds present in the extracts with their retention time (RT), concentration (peak area %), metabolic group, and molecular formula are presented in Table 3. A total of 28 different organic compounds were identified for *B. insignis*, none of which are shared by all the plant parts (Additional file 1: Fig. S1). Almost half of them appeared in the flower fraction, being the extract with the highest diversity of compounds (Table 3). Volatile compounds such as di and triterpenes, fatty acid methyl esters, alkanes, and triglycerides were found in the extracts, having most of these, different relative percentage for each plant part. Some molecules were found to be exclusive to a particular extract. This fact was especially noticeable in the roots, where monoterpenoid compounds found were exclusive to that extract.

Discussion

Polyphenols constitute the secondary metabolites found in various plants which modulate the activities of a wide variety of enzymes and cell receptors, besides having important bioactivities as antioxidant and protection against ultraviolet radiation (Kumar et al. 2019). The content of these compounds in *B. insignis* shows flower and leaf extract present a higher content of polyphenol. Similar results were found by Hudec et al. 2007 in the extract of *Echinacea purpurea*, showing also higher polyphenol content in flower (46 mg GAE/g extract) and leaf (40 mg GAE/g extract). Plants produce phenolic compounds that have different functions including defense mechanism against herbivory by animals or microorganisms (Xue et al. 2018).

Table 3 GC–MS profile of the different parts of *B. insignis*

Compound	Flower		Fruit		Leaves		Root		Stem		Metabolite group
	RT	*%Area*	*RT*	*%Area*	*RT*	*%Area*	*RT*	*%Area*	*RT*	*%Area*	
Neophytadiene	19.24	1.4	19.24	0.46	19.24	1.71	–	–	19.28	15.93	Diterpene
Phytol	19.68	0.75	–	–	19.68	10.25	–	–	–	–	Diterpene alcohol
Methyl palmitate	20.17	3.14	–	–	20.19	8.59	–	–	–	–	Fatty acid methyl ester
Methyl linolenate	21.82	1.61	–	–	21.85	16.56	–	–	–	–	Fatty acid methyl ester
Icosane	23.47	4.38	–	–	–	–	–	–	–	–	Alkane
Di(2-ethylhexyl) adipate	24.35	1.87	24.31	8.83	–	–	–	–	24.39	14.25	Diester
2,6,10,15-tetramethylheptadecane	25.08	1.12	–	–	–	–	–	–	–	–	Alkane
Methyl behenate	25.44	2.66	–	–	25.35	12.24	–	–	25.36	26.79	Fatty acid methyl ester
n-octacosane	26.57	2.95	–	–	–	–	–	–	–	–	Alkane
Methyl tetracosanoate	26.83	2.23	–	–	26.87	21.69	–	–	26.83	12.59	Fatty acid methyl ester
Squalene	27.52	13.06	–	–	27.52	5.65	–	–	27.52	23.52	Triterpene
n-tetratetracontane	27.96	7.38	–	–	–	–	–	–	–	–	Alkene
Glycerol tricaprylate (Tricaprylin)	28.33	56.57	28.33	20.51	28.34	5.36	–	–	–	–	Triglyceride
Palmitic acid	–	–	20.81	3.47	–	–	–	–	–	–	Saturated fatty acid
Clionasterol	–	–	21.87	3.91	–	–	–	–	–	–	Triterpenoid
(9Z)-9-Octadecenal (Olealdehyde)	–	–	24.6	0.32	–	–	–	–	–	–	Aldehyde
Hexatriacontane	–	–	26.33	2.15	–	–	–	–	–	–	Alkane
Nonacosane	–	–	27.28	18.77	–	–	–	–	–	–	Alkane
1,2,3-propanol tridecanoate (Tricaprin)	–	–	27.44	41.31	–	–	–	–	–	–	Triglyceride
n-docosane	–	–	–	–	26.83	4.36	–	–	–	–	Alkane
Methyl henicosanoate	–	–	–	–	24.87	4.4	–	–	–	–	Fatty acid methyl ester
n-tetracosane	–	–	–	–	24.33	9.2	–	–	–	–	Alkane
β-Citronellene	–	–	–	–	–	–	10.17	27.93	–	–	Monoterpenoid
Myrtanal	–	–	–	–	–	–	10.94	11.32	–	–	Monoterpenoid
β-pinene epoxide	–	–	–	–	–	–	11.06	31.17	–	–	Monoterpenoid
cis-Myrtanol	–	–	–	–	–	–	12.28	14.19	–	–	Monoterpenoid
Myrtenol	–	–	–	–	–	–	12.41	15.39	–	–	Monoterpenoid
5-Methyloctadecane	–	–	–	–	–	–	–	–	20.5	6.91	Alkane

RT: retention time; %Area: relative amount. In different colors, compounds exclusive to a particular organ are shown

Flavonoids are low molecular weight phenolic compounds having a benzo-γ-pyrone structure present ubiquitously throughout the plant kingdom, presenting numerous properties such as antimicrobial, anticancer, and antiaging activities (Xue et al. 2018). Flower and leaf extract present a higher content of flavonoids. Baba and Malik (2014) found similar content of total flavonoids in extracts of leaf of *G. kurroo* (20 ± 1.8 mg rutin/g extract). Jadouali et al. (2017) also reported values of total flavonoids content of 34.23 QE/g extract of whole flower from *Crocus sativus* L., being the petals the main source of flavonoids in the flower.

In this study, the highest content of saponins in *B. insignis* was found in roots. Similar yields were reported for *Quillaja brasiliensis*, commonly known as "soap tree" because its saponins produce persistent foam in water. Leaves from adult trees and barks showed an average saponin content of 0.085 and 0.022 (% dry weight) (Magedans et al. 2019) Since the ethnopharmaceutical uses of this plant imply the preparation of infusions from leaves, it might be that these compounds synergistically contribute to the overall anti-inflammatory and antirheumatic process.

Studies about the biological properties of *B. insignis* showed that the extracts presented a more pronounced antimicrobial activity against the Gram-negative *E. coli*, while *S. aureus* and *P. larvae* (both Gram-positive) remained the most resistant bacteria. Similar results were found in flower extracts of *Tribulus terrestris* and *Pavetta indica* with MIC of 0.62 mg/mL against *E. coli* and 0.6 mg/mL and 1.3 mg/mL, respectively, against *S. aureus* (Sujatha and Prakash 2013). In addition, leaves of *Moringa oleifera* showed values of MIC of 0.78 mg/mL against *E. coli* and *S. aureus* (Tshabalala et al. 2020). Previous works reported the antibacterial activity of root extracts of different plants against diverse pathogens like *Salmonella enteritidis*. *E. coli*. *S. aureus* and *P. aeruginosa*, among others (Baba and Malik 2014), (Ogbole et al. 2018). Similar MIC results were reported for ethanolic and aqueous extracts of root from *Moringa oleifera* (1.56 and 3.12 mg/mL, respectively). The antibiotic activity of botanical extracts has been reported to be higher against Gram-positive than on Gram-negative bacteria (Nasar-Abbas and Halkman 2004).

The DPPH radical assay is an appropriate model for estimating the total antioxidant potential of antioxidants (Nono et al. 2014). Root extract values are in the range of those reported for root extracts of *Dissotis thollonii* Cogn. and *Sarcopoterium spinosum* of 2.26 to 18.37 μmol TEAC/g (Al-Mustafa and Al-Thunibat 2008) that also showed anti-inflammatory and antiarthritic properties. The higher DPPH radical scavenging ability observed in the leaves and flowers could be attributed to the higher content of flavonoids and polyphenols which contain at least one benzene ring with one or more hydroxyl groups (Kumar et al. 2019). This study suggests that *B. insignis* is potentially a good source of antioxidants, which can be incorporated into diet plans, skin products, and antiaging products.

Gas chromatography–mass spectroscopic analysis showed that compounds of the different organs of *B. insignis* presented a great chemical variability, including aliphatic alcohols, esters, terpenes, terpenoids, phenylpropanoids, among others (Cseke et al. 2016). Many of these molecules are the components of the essential oils, present in certain species or groups of plants. Many of them are known for their biological properties, namely phytol, which is frequent in aerial parts of different medicinal vascular plants and in algae it is a diterpene that has antimicrobial activity, antioxidant and anticancer properties (Lorenz et al. 2009). One of the compounds with the greatest presence in the aerial parts was squalene, a compound present in some fish oils, exclusively in shark liver oil and quite common in plants. It has a long list of medicinal and cosmetic properties (Kim and Karadeniz 2012). Another interesting metabolite is methyl tetracosanoate, a fatty acid methyl ester, mainly present in leaves and stems of *B. insignis*, which has antidiabetic properties even at low concentrations (Shilpa et al. 2009).

All the compounds found in root were exclusive to that extract. It should be noted that all of these five components are monoterpenoids, and some can be reconverted into others, as in the case of β-pinene epoxide and myrtanol, which are oxidation products of myrtanal. Organic compounds analyzed by GC–MS are mostly lipophilic metabolites of variable molecular weight. In this work, the volatile content was evaluated by discriminating the different aerial parts and roots of *B. insignis* plants in the reproductive stem. The type and concentration of nectar were previously reported for some genera and species of the family (Huang et al. 2012) but there are no records of volatile compounds in Loasaceae, this work being the first report for the family.

Conclusions

B. insignis, an unexplored endemic species from South America was chemically characterized, in order to understand its ethnopharmaceutical uses. In the present study, extracts from different parts of *B. insignis* had significant antioxidant and antibacterial activities. In addition, all extracts showed antimicrobial activity against bacteria of clinical importance such as *E. coli* and *S. aureus*, as well as against *P. larvae*, a bee pathogen. From these results, we can infer that the extracts could be used as antimicrobials of natural origin to

replace synthetic antibiotics that leave residues and are not desirable in beekeeping. These features could be useful to prevent or slow the progress of various oxidative stresses and against pathogenic bacterial strains. Interesting bioactive compounds such as polyphenols, flavonoids, and saponins were found in different aerial parts as well as in the roots, showing these latter important rates of monoterpenes. Further studies such as "in vitro" and "in vivo" pharmacological evaluation would be necessary to determine the safety and efficacy of extracts from different parts of this plant, in order to implement their phytopharmaceutical use.

Abbreviations

DNA: Deoxyribonucleic acid; ROS: Reactive oxygen species; GC–MS: Gas chromatography–mass spectrometry; GAE: Gallic acid equivalents; QE: Equivalents of quercetin; DPPH: 1,1-Diphenyl-2-picrylhydrazyl; Trolox: 6-Hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid; TEAC: Trolox equivalent antioxidant capacity; ANOVA: Analysis of variance; MBC: Minimum bactericidal concentration; MIC: Minimal inhibitory concentrations; RT: Retention time.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s42269-022-00957-z.

Additional file 1. Supplementary information.

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Author contributions

FF, CF, and RC conceived this research and designed the experiments; FF, BG, MS, and RC participated in the interpretation of the data; FF, BG, MS, and RC performed the experiments and analysis; FF, BG, and RC wrote the paper. All authors read and approved the final manuscript.

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Availability of data and materials

Data are available from the authors upon request.

Declarations

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Not applicable.

Consent for publication

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Competing interests

The authors declare that they have no competing interests.

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