eISSN 2236-5257
10.46551/ruc.v27n2a10

Diplopterys pubipetala: review of traditional use, phytochemical and potential health benefits

Diplopterys pubipetala: revisão do uso tradicional, fitoquímico e potenciais benefícios à saúde

Veronica de Melo Sacramento[1]
Pedro Henrique Fonseca Veloso[2]
Kamila Soares Freitas Souto[3]
Eurislene Moreira Antunes Damasceno[4]
Luís Henrique Rodrigues Rocha[5]
Elytânia Veiga Menezes[6]
Afrânio Farias de Melo Júnior[7]
Dario Alves de Oliveira[8]
Tânia Maria de Almeida Alves[9]
Vanessa de Andrade Royo[10]

ABSTRACT

Objective: To compile and synthesize studies addressing the ethnobotanical and phytochemical characteristics of *D. pubipetala*. **Methodology:** A comprehensive literature

[1] Pós-doutoranda em Biotecnologia - UNIMONTES. Doutora em Biotecnologia pela Universidade Estadual de Montes Claros - MG. veronica.sacramento.2014@gmail.com. https://orcid.org/0000-0002-5956-1457.
[2] Doutorando em Biotecnologia - UNIMONTES. Mestre em Biotecnologia pela Universidade Estadual de Montes Claros - MG. pedrofonsecambc@gmail.com. https://orcid.org/0000-0003-2802-1244.
[3] Graduada em Ciências Biológicas pela Universidade Estadual de Montes Claros - MG. kamilasoares08@gmail.com. https://orcid.org/0009-0004-1084-1679.
[4] Doutoranda em Biotecnologia- UNIMONTES. Mestre em Cuidado Primário pela Universidade Estadual de Montes Claros - MG. lene.euris@yahoo.com.br. https://orcid.org/0000-0002-6381-7531.
[5] Graduando em Ciências Biológicas pela Universidade Estadual de Montes Claros - MG. luisrrocha732@gmail.com. https://orcid.org/0000-0003-3815-450X.
[6] Docente do Programa de Pós-graduação em Biotecnologia - UNIMONTES. Doutora em Genética pela Universidade de São Paulo - SP. menezes.elytania@gmail.com. https://orcid.org/0000-0003-2574-9360.
[7] Docente do Programa de Pós-graduação em Biotecnologia - UNIMONTES. Doutor em Engenharia Florestal pela Universidade Federal de Lavras - MG. afraniofariasdemelo@gmail.com. https://orcid.org/0000-0001-7899-3979.
[8] Docente do Programa de Pós-graduação em Biotecnologia - UNIMONTES. Doutor em Fitotecnia pela Universidade Federal de Viçosa - MG. dario.aol@gmail.com. https://orcid.org/0000-0002-8161-4607.
[9] Pesquisadora titular da Fundação Oswaldo Cruz - FIOCRUZ. Doutora em Química pela Universidade Federal de Minas Gerais - MG. tania.alves@fiocruz.br. https://orcid.org/0000-0002-0582-3968.
[10] Docente do Programa de Pós-graduação em Biotecnologia - UNIMONTES. Doutora em Produtos Naturais e Sintéticos pela Universidade de São Paulo - SP. vanroyo31@gmail.com. https://orcid.org/0000-0002-4842-3569.

Recebido em	Aceito em	Publicado em
15-04-2025	10-09-2025	25-09-2025

search was conducted using databases such as Google Scholar, ScienceDirect, SciELO, Capes journals, and academic books, encompassing ethnobotanical, ethnopharmacological, and phytochemical data. Results: The species exhibits a Variety of secondary metabolites, including phenolic compounds, alkaloids, and terpenes. Its alkaloid profile resembles that of Banisteriopsis caapi, a principal component of Ayahuasca, which has demonstrated therapeutic potential. Notable antioxidant activity was identified in leaf and stem extracts, likely due to flavonoids. Additionally, in vitro studies revealed cytotoxic, anti-inflammatory, and anti-metastatic effects. **Conclusion:** Further investigation into the species' secondary metabolites is warranted to ensure safety and support the exploration of its pharmacological potential, particularly regarding antimicrobial, antifungal, and in vivo applications.

Keywords: *Diplopterys pubipetala*; *Banisteriopsis pubipetala*; Ayahuasca tea; Antioxidant activity; Anti-inflammatory action.

RESUMO

Objetivo: Compilar e sintetizar estudos abordando as características etnobotânicas e fitoquímicas de *D. pubipetala*. **Metodologia:** Uma busca bibliográfica abrangente foi conduzida usando bases de dados como Google Acadêmico, ScienceDirect, SciELO, periódicos Capes e livros acadêmicos, abrangendo dados etnobotânicos, etnofarmacológicos e fitoquímicos. **Resultados:** A espécie exibe uma variedade de metabólitos secundários, incluindo compostos fenólicos, alcaloides e terpenos. Seu perfil alcaloide assemelha-se ao de *Banisteriopsis caapi*, um dos principais componentes da Ayahuasca, que demonstrou potencial terapêutico. Notável atividade antioxidante foi identificada em extratos de folhas e caules, provavelmente devido aos flavonoides. Além disso, estudos *in vitro* revelaram efeitos citotóxicos, anti-inflamatórios e antimetastáticos. **Conclusão:** Investigações adicionais sobre os metabólitos secundários da espécie são necessárias para garantir a segurança e apoiar a exploração de seu potencial farmacológico, particularmente em relação às aplicações antimicrobianas, antifúngicas e *in vivo*.

Palavras-chave: *Diplopterys pubipetala*; *Banisteriopsis pubipetala*; Chá de Ayahuasca; Atividade antioxidante; Ação anti-inflamatória

INTRODUCTION

The Malpighiaceae family is one of the most diverse, consisting of shrubs and vines predominantly found in neotropical regions of the Americas[1,2]. About 45 genera and 529 species are distributed in Brazil, especially in the Cerrado and Atlantic Forest biomes[3]. In this family, many genera are commonly explored for knowledge and to obtain bioactive

compounds that may serve as components with phytotherapeutic or medicinal utility[4]. The search for bioactive molecules of plant origin aligns with the success of drug development, as medicinal plants based on traditional knowledge are typically the initial source for chemical syntheses[5].

The genus *Diplopterys* comprises 31 species in dry and humid tropical forests in the neotropics[6,7]. *Diplopterys pubipetala* (A.Juss.) W. R. Anderson & C. Davis (*Banisteriopsis pubipetala* (A. Juss.) Cuatrec.) is the species of interest in this review study. *D. pubipetala* belongs to the genus *Diplopterys* A. Juss., which, together with the genus *Banisteriopsis* C.B. Rob., are considered sister genera, both due to the similarity of floral structure[6] and molecular data analysis[7]. Thus, some materials selected in this investigation still bear the designation *B. pubipetala*.

Known as "cipó-preto, cipó-de-rego, or crista-de-galo"[6]; "tucunacá" in the Brazil North region[8], and "marvaquero" by locals in the northern state of Minas Gerais, the vine *D. pubipetala* is one of the more than 1315 species belonging to the Malpighiaceae family[9]. It is widely distributed throughout Brazil, often found in forests and cerrados of the Espinhaço Range and Central Plateau, can reach up to one and a half meters in height, and presents itself as a climber when mature. Flowers develop in September, and November is the fruiting period[3,10,11].

METHODOLOGY

A comprehensive literature review on *Diplopterys pubipetala* was carried out using databases such as Google Scholar, ScienceDirect, SciELO, and Web of Science, in addition to specialized journals. The search included original research articles, review papers, and technical bulletins published between 1980 and 2024, with the objective of compiling data related to the ethnobotanical, ethnopharmacological, and phytochemical aspects of the species. The review was guided by specific descriptors, including the following terms and/or their combinations: "Malpighiaceae", "*Diplopterys pubipetala*", "*Banisteriopsis pubipetala*", "secondary metabolites", "phytochemistry", "bioactive compounds", "histochemistry", "chemical composition", "chemical compound", "antioxidant activity", "extract", and "natural substances". The exclusion criteria comprised conference abstracts, as well as theses and

dissertations that had not been published in peer-reviewed journals, even when falling within the time frame defined for this study.

Chemical composition - Histochemical tests

In the leaf tissues of *D. pubipetala*, histochemical tests revealed a greater distribution of secondary metabolites, with flavonoids, alkaloids, and terpenes observed in the epidermis, periderm, and palisade parenchyma. In the stems, these classes were more evident in the epidermis. Commonly, calcium oxalate crystals were also observed in these tests[12].

In the chemical analysis of species *Stigmaphyllon auriculatum*, *Stigmaphyllon ciliatum*, and *Stigmaphyllon paralias*, the metabolites present in common in leaves and aerial stems were quaternary alkaloids, condensed tannins, triterpenes, flavones, and flavonols. Saponins and quinones were limited to *S. ciliatum* and *S. paralias*. Resins were identified only in *S. auriculatum*. Chalcones and aurones were common in the underground parts of the three species investigated[13].

It was verified through histochemical tests of the leaf blade that hydrophilic components, including polysaccharides and reducing sugars, are present, and that in the outermost layer of the cuticle of *D. pubipetala* it reacts to the presence of lipids, while the inner layer contains pectin and mucilages[14]. The leaf and calyx glands of *Banisteriopsis campestris*, *Banisteriopsis laevifolia*, and *Banisteriopsis malifolia* produce secretions[15] determined by a mixture of proteins, lipids and polysaccharides.

The histochemical tests[11] in fresh wood from the stem and bark of *D. pubipetala* revealed mainly the presence of alkaloids, phenolic compounds, tannins and terpenoids from essential oils were also found, while saponins were barely noticeable in the bark and wood.

Histochemical analyses of mature caliciform glands revealed the excretion of phenolic substances, polysaccharides, and proteins into the subcuticular space of elaiophores[16]. The presence and accumulation of lipid content in this subcuticular space have also been reported in Malpighiaceae species: *Banisteriopsis sericea*, *Dinemandra ericoides*, *Heteropterys chrysophylla*, *Malpighia coccigera* and *Peixotoa hispidula*[15].

Chemical composition of flowers

In general, lipids are present in the cuticles of the calyx, corolla, and androecium glands; proteins, pectin, mucilages, polysaccharides, and phenolics are found in the epidermis

of these glands; these substances were also detected in the cell walls except for proteins; terpenes are only present in the epithelial cells of the corolla and staminal glands; translucent and slightly viscous exudates, which are mucilages and polysaccharides, appear on the surface of the connective tissue of the androecium glands[16,17]. The floral odors, of lipophilic nature, produced by the osmophores present in the petal glands, were perceived through positive color reaction and ultrastructural analysis[16]. For species of *Byrsonima gardneriana*, *Byrsonima coccolobifolia*, and *Byrsonima verbascifolia*, it was found that the flowers do not have a perceptible odor and remain receptive for two days in the case of the first two species, while the last species remains receptive for about 72 hours[18].

The variation in the chemical composition of floral oils was observed in some species[19], *Peixotoa tomentosa* contains acylglycerols available at the peak of the dry season, while for the species *B. campestris* and *B. malifolia*, the highest abundance occurred in the rainy period of summer, with a highlight on disubstituted fatty acids. In the case of the species *Pterandra pyroidea*, based on gas chromatography and mass spectrometry analysis, the fatty acid detected in greater quantity as a methyl ester derivative in floral oils was 5,7-diacetoxidocosanoic acid[20] . For the species *Byrsonima intermedia*, the major component of floral oil is the isomer of the previously mentioned acid, described as byrsonic acid[21]. Tricosanoic acid, palmitic acid, and heneicosanoic acid were the main constituents of the floral oil discovered in *B. sericea*[22] .

Seeds composition

Phenolic substances are present in the seed layers of *D. pubipetala*, as well as in the mature fruit, whose structure is lignified and also contains pectic substances[23]. The embryonic reserve of *D. pubipetala* is primarily composed of lipids, with scattered starch grains and numerous druses. Developing seeds exhibit an outer epidermis formed by cells with a high density of phenolic compounds[24].Two studies refer to the fatty acid composition of the seeds: Pinho et al. (2009)[25] and the more recent one, Prazeres et al. (2017)[26]. In the former, analysis was conducted using gas chromatography coupled with electron impact mass spectrometry; whereas in the latter, it was performed through gas chromatographic analysis (headspace technique) coupled with mass spectrometry.

Both studies found a predominance of unsaturated fatty acids in the seeds, reaching 71.0% in the first investigation. The quantity of linoleic acid (C18:2) prevailed, being 42.8%[25]

and 39.2%[26]. Other unsaturated fatty acids included linolenic acid (C18:3) (21.1%) and palmitoleic acid (C16:1) (7.11%)[25], although oleic acid (C18:1) was not observed in the former study, where it was the second most abundant (32.6%) in the more recent one. Saturated fatty acids were also prominent, with palmitic acid (C16:0) at 17.6%[25]and 25.7%[26].

The acids found in higher quantities in *D. pubipetala* seeds also correspond to those present in acerola seeds, *Malpighia glabra*. Linoleic acid, considered essential, is a substance not produced by animals; it is a valuable nutrient for the human diet. Although it has recognized nutritional value in many aspects as a precursor to hormones like prostaglandins and its involvement in physiological processes related to the prevention and treatment of cardiovascular diseases, diabetes, arthritis, and various inflammatory diseases, there remain contradictory issues regarding the ideal dietary levels to avoid adverse effects on human health[27,28,29]. The other fatty acid, however, saturated, is palmitic acid, which can be useful in cosmetic formulations, biodiesel production, among other applications[27].

Minerals

The therapeutic effects demonstrated by medicinal plants are related to the peculiarities of their chemical composition, not only of the physiologically active substances they synthesize and accumulate, but also of the different classes of secondary metabolites—such as alkaloids, phenolics, terpenoids, and others—as well as the comprehensive profile of macro- and microelements of biological relevance[30].

Seeds of *D. pubipetala* were investigated for the composition of the minerals sodium, potassium, calcium, magnesium, iron, copper, chromium, and aluminum (Na, K, Ca, Mg, Fe, Cu, Cr, Al) using high-resolution continuum source atomic absorption spectrometry, and for phosphorus (P), the colorimetric method of vanadomolybdophosphoric acid was used[31].

The elements Cu, Cr, and Al did not reach the detection limit; all were below 0.11 $\mu g.g^{-1}$. The most abundant macroelement was K ($1636 \pm 135\ \mu g.g^{-1}$), while the quantity of the trace element Fe ($3.69 \pm 0.03\ \mu g.g^{-1}$) compared to other investigated seeds was relatively low. The others, in descending order, are Mg ($447 \pm 13\ \mu g.g^{-1}$), P ($288 \pm 55\ \mu g.g^{-1}$), Ca ($134 \pm 6\ \mu g.g^{-1}$), and Na ($38 \pm 1\ \mu g.g^{-1}$)[31].

The homeostasis of metallic ions is essential for plant development, and the careful regulation of processes is crucial to avoid deficiencies or toxicity of metallic ions. Therefore, there is a constant need to acquire each nutrient that meets the requirements of this dynamic

process, which involves mobilization, absorption, and distribution within the plant, intracellular trafficking, and storage, as well as redox activities, with emphasis on Fe, Cu, and Cr[32].

Minerals are relevant concerning physiological and environmental importance; they play a role in maintaining and restoring health. Deficits in intake can lead to an increase in diseases and can serve as indicators of environmental contamination. The data obtained can also contribute to understanding the relative potential for human and animal consumption in the form of dietary supplements[31,33].

In this regard, literature reports mineral quantification in maturing acerola fruit (*M. glabra*), with potassium (K) being prominent (150.43 $mg.100g^{-1}$), similar to the findings in *D. pubipetala* seeds. This is followed by magnesium (Mg) (16.57 $mg.100g^{-1}$), calcium (Ca) (12.90 $mg.100g^{-1}$), iron (Fe) (7.06 $mg.100g^{-1}$), and sodium (Na) (7.56 $mg.100g^{-1}$)[33]. For green fruits[34] of *M. emarginata*, noteworthy results were also related to the presence of potassium (K) (2414.20 ± 0.01 $mg.100g^{-1}$) and calcium (Ca) (518.69 ± 12.27 $mg.100g^{-1}$) in the white flower variety. For other macrominerals (Ca, K, Mg, and Na), concentrations in the three investigated varieties generally ranged from 0.86 ± 0.02 to 2414.14 ± 0.01 $mg.100g^{-1}$, while for microminerals (Mn, Cu, Fe, and Zn), values varied from 0.21 ± 0.03 to 4.15 ± 0.21 $mg.100g^{-1}$, with white flower again having the highest quantities.

Phytochemical and chromatographic screening test

The phytochemical investigation of the hydroethanolic extract from leaves and stems of *D. pubipetala* revealed the presence of compounds that may contribute to the medicinal potential of this plant, whether as anti-inflammatory, antimicrobial, or antioxidant agents. Among the constituents are flavonoids, glycosylated flavonoids, alkaloids, tannins, terpenes, and prenylated xanthones[12]. Consistent with this investigation, another study on ethyl acetate, dichloromethane, and butanol partitions of leaves and stems in *D. pubipetala* identified five distinct classes of secondary metabolites: alkaloids, flavonoids, terpenoids, saponins, and lactones, consisting of 10 identified components[35].

For three species of *Banisteriopsis* (*B. stellaris*, *B. adenopoda*, *B. argyrophylla*) in areas of the Cerrado, under different climatic seasons and developmental stages, the concentration of tannins was compared over two years of study. The highest amount was

present in old leaves during the dry season, which is related to leaf exposure time and water stress[36].

Similarly, chromatographic analysis[12] revealed that the major components contained in the ethyl acetate partition obtained from the hydroethanolic extract of stems and leaves were consistent, although the latter presented double the number of substances evidenced by peaks. Analysis of the absorption spectra allowed the inference that three compounds belong to the same class of secondary metabolites. The absorption of ultraviolet light between 320 and 385 nm is attributed to the B-ring of the benzene structure, while a second absorption band between 250 and 285 nm corresponds to the A-ring, which is characteristic of flavones and flavonols[37]. Further consistent with these findings, it was found that there is a higher concentration of these substances in the leaf than in the stem, thus aligning with the result presented in the phytochemical investigation[12].

Through direct infusion analysis in electrospray ionization (ESI), the provisional identification of eight substances belonging to the crude hydroethanolic extract of leaves and stems was obtained. The substances were detected by ESI(+) positive mode (protonated form $[M + H]^+$ and/or as sodium adducts $[M + Na]^+$), or in the deprotonated form $[M - H]^-$, ESI(-) negative mode, with four of them common to both extracts[12] namely: hexose ($C_6H_{12}O_6$), haematomatte ($C_9H_8O_5$), dambonitol ($C_8H_{16}O_6$), and verticoglucuronic acid ($C_{15}H_{18}O_{10}$).

The other substances with relative intensity in the leaf extract were: 1-isomangostin and/or 3-isomangostin ($C_{24}H_{27}O_6$); mangostenol and/or mangostanol ($C_{24}H_{27}O_7$); apigenin, galangin, and/or glycosylated genistein ($C_{21}H_{20}O_{10}$); glycosylated kaempferol ($C_{24}H_{16}O_9$)[12].

Cucurbitin A ($C_{29}H_{28}O_{11}$), syringetin 3-glucuronide ($C_{23}H_{22}O_{14}$) and macarangaflavanone ($C_{25}H_{28}O_5$) were identified in the ethyl acetate leaf partitions and the latter of them in butanol. Among the described actions for syringetin 3-glucuronide are antioxidant, anti-allergic, and anti-inflammatory; and for macarangaflavanone A, antimicrobial activity is described[35].

The substance kaempferol was also the subject of study, as well as quercetin and catechin belonging to the ethanolic extract of *B. argyrophylla* leaves, in which 10 flavonoids with biological activity were identified[38], and in another study, bioactive compounds such as procyanidins and megastigmane glycosides were identified[39].

In the ethanolic extract of leaves and flowers of *B. laevifolia*, through high-performance liquid chromatography coupled with tandem mass spectrometry, 7 compounds reported for the first time were identified, including flavonoids and terpenoids[40]. The phytochemical screening[41] of this species also indicated the presence of phenols, steroids, sugars, and tannins.

Regarding the terpenes of *D. pubipetala*, phytuberin ($C_{17}H_{26}O_4$) stood out, which was identified in all leaf partitions and in the stem partition of dichloromethane, with antimicrobial and antifungal actions[35]. Additionally, ginsenoside Rh2 ($C_{36}H_{62}O_8$) was identified in the butanol leaf partition, a molecule considered important as it can inhibit glutamate action and possesses anti-obesity properties and risk factors reducers for metabolic diseases such as diabetes[35].

Alkaloids were more evident in the more polar partition (butanol), among them are: N-cis-feruloyltyramine ($C_{18}H_{19}NO_4$) with potential anticarcinogenic, anti-inflammatory, antioxidant, and antifungal biological activity; and the alkaloid simulansamide ($C_{22}H_{23}NO_6$) capable of inhibiting platelet aggregation[35].

Although alkaloids are present in several Malpighiaceae species, they are predominantly restricted to vine genera such as *Banisteriopsis*, *Diplopterys*, *Tetrapterys*, and *Stigmaphyllon*[36,42]. The widespread occurrence of alkaloids in Banisteriopsis and related genera like *Diplopterys* supports the diversity of plant species used in the preparation of Ayahuasca tea[11]. This also highlights the challenge in distinguishing among users, who often collect and utilize different species interchangeably, given the similar hallucinogenic effects elicited by these alkaloids.

Ethnobotanic aspects: Ayahuasca tea

The Ayahuasca tea is characterized by the psychoactive effects caused by the synergistic interaction between alkaloids present in the bark and stems of *B. caapi* (Spruce ex Griseb.) Morton (Malpighiaceae) and the leaves of the species *Psychotria viridis* Ruiz & Pav. (Rubiaceae)[43]. It is known that other species of *Banisteriopsis* can also replace the *B. caapi* species in a similar way, and *D. pubipetala*, by presenting several similarities with the genus, has also been explored and referred to as "Ayahuasca analogue," as it represents a non-traditional combination with the same active principle[11,8].

Studies on the bioactive properties of Ayahuasca tea associate it with beneficial effects in various physical and psychological conditions, particularly in the treatment of depression, anxiety, and various neurobiological diseases such as degenerative diseases, severe physical illnesses, cancer, chronic conditions, post-traumatic stress disorders, personality disorders, Parkinson's, and Alzheimer's diseases, as well as possessing anti-inflammatory and antimicrobial properties, demonstrating its therapeutic potential[44].

Research conducted with 176 vegetal lianas, including 159 samples of *B. caapi* and 33 samples of Ayahuasca, aimed to verify the presence of *β*-carboline alkaloids in this infusion. Only one sample out of the five samples of *D. pubipetala* contained *β*-carbolines, with 0.16 $mg.g^{-1}$ of harmine, 0.046 $mg.g^{-1}$ of harmaline, and 1.04 $mg.g^{-1}$ of tetrahydroharmine. The other four samples from the central region of Brazil possibly affected by factors related to environmental conditions, organic and inorganic soil composition, and the biosynthesis of these compounds did not have detectable minimum amounts (LOD) and values below 0.0009 $mg.g^{-1}$, 0.0018 $mg.g^{-1}$, and 0.0146 $mg.g^{-1}$, respectively[48].

Quantification of phenolic compounds

Phenolic compounds in the hydroethanolic extracts of leaves and stems of *D. pubipetala* were quantified using the Folin-Ciocalteu method. The results were expressed in mg $GAE.g^{-1}$ (milligrams of gallic acid equivalent per gram of extract) obtained by interpolation of the sample absorbance relative to the calibration curve, resulting in 146.09 ± 3.31 mg $GAE.g^{-1}$ and 100.19 ± 9.26 mg $GAE.g^{-1}$, respectively, with the leaf and stem extract showing nearly 50% higher value[12].

For *B. laevifolia*, phenolics quantification resulted in 288.67 ± 0.04 mg $GAE.g^{-1}$ (ethanolic extract of flowers) and 225.67 ± 0.07 mg $GAE.g^{-1}$ (ethanolic extract of leaves)[40] In the same species, reported[41] 542.0 ± 2.1 mg $GAE.g^{-1}$ for the ethanolic leaf extract and 784.7 ± 5.6 mg $GAE.g^{-1}$ for the n-butanol partition, with the ethyl acetate partition also noteworthy at 660.0 ± 1.5 mg $GAE.g^{-1}$.

For the ethanolic leaf extract[39] of *B. argyrophylla*, the total phenolics content was 337.1 ± 1.4 mg $GAE.g^{-1}$. For *B. gardneriana*, values obtained were 425.105 ± 8.523 mg $GAE.g^{-1}$ for the crude extract and the highest content of 509.947 ± 7.387 mg $GAE.g^{-1}$ for the ethyl acetate fraction, followed by the butanol (492.261 ± 4.904 mg $GAE.g^{-1}$),

trichloromethane (243.29 ± 3.897 mg GAE.g^{-1}), and hexane (80.42 ± 0.693 mg GAE.g^{-1}) fractions[49].

Phenolic antioxidants can act by molecularly altering free radicals to neutralize them, chelating metals, and hindering the initiation and propagation steps of lipid peroxidation[50]. These abilities are related to the structural heterogeneity of phenolic compounds found in plants, which allow variable solubility in organic solvents and water, enabling various actions in plants such as defense against pathogens and herbivores, attraction to pollinators or fruit dispersers, and allelopathic effects[51]. For human health, the antioxidant power of these phenolic compounds contributes to the body's defenses, potentially affecting various important pathological pathways, including cardiovascular diseases, neurodegenerative diseases, diabetes, inhibition or retardation of cancer cells, and slowing down the aging of cells in general[52,53].

Quantification of flavonoids

The quantification of total flavonoids was also carried out for the leaf and stem extracts of *D. pubipetala*, and the concentrations obtained were expressed in mgQ.g^{-1} or mgR.g^{-1} (mg of quercetin equivalent per gram of extract or mg of rutin equivalent per gram of extract) namely: 20.25 ± 0.39 mgQ.g^{-1} and 88.15 ± 4.41 mgR.g^{-1} for leaf extract, and 7.75 ± 0.45 mgQ.g^{-1} and 23.09 ± 4.56 mgR.g^{-1} for stem extract[12] These values are consistent with the higher phenolic content obtained for the leaf extract compared to the stem extract. Such values were low when compared to those obtained for B. laevifolia: 199.87 ± 0.13 mgAG.g^{-1} (mg of gallic acid equivalent per gram of extract) for flower extract and 173.30 ± 0.08 mgAG.g^{-1} for leaf extract, expressed[40] in mgAG.g^{-1} whereas in a previous study[41], obtained 61.2 ± 0.4 mgQ.g^{-1} for the crude leaf ethanol extract, with the partitions with higher values being 88.8 ± 3.5 mgQ.g^{-1} for ethyl acetate and 77.2 ± 1.8 mgQ.g^{-1} for dichloromethane.

As for the values obtained for the extract and fractions of *B. argyrophylla*, they were very close in the ethanol extract and hexane fraction (71.8 ± 0.3 mgQ.g^{-1} and 71.0 ± 1.9 mgQ.g^{-1}, respectively). Among the other fractions, the highest highlight, as with *B. laevifolia*, was reserved for the ethyl acetate fraction 211.9 ± 2.9 mgQ.g^{-1}, which surpassed all the previous ones[39].

Antioxidant activity

The EC_{50} (efficiency concentration) values of the leaf and stem extracts of *D. pubipetala* were respectively 25.42 μg.mL^{-1} and 50.73 μg.mL^{-1}, while the calculations for the AAIs (antioxidant activity indices): 1.6 and 0.79 respectively demonstrated that the antioxidant activity of the hydroethanolic leaf extract is excellent while for the stems it is moderate. These values corroborate with the previous quantifications, as the increased antioxidant potential is attributed to samples with a higher presence of phenols and flavonoids[12] In this study, the DPPH (2,2-difenil-1-picrilhidrazil) radical method was used, in which the EC_{50} value (concentration required to inhibit the DPPH radical by 50%) was obtained from spectrophotometric reading at 517 nm.

Antioxidant activity using the DPPH radical method was also measured for leaf extract and fractions of *B. laevifolia*. Among the values obtained, it can be highlighted that the ethanolic leaf extract 107.21 ± 0.09 μg.mL^{-1} was not as good as that of the flowers 24.38 ± 0.07 μg.mL^{-1}, which was compatible with the standard substance used, and all subfractions had values considered moderate[40] Still for this species, the investigation[41] carried out obtained EC_{50} for the ethanolic extract 4.5 ± 0.9 μg.mL^{-1} and for the ethyl acetate partition resulted in 4.1 ± 0.5 μg.mL^{-1}, these values were very close to that obtained for the standard substance used (butylated hydroxytoluene), therefore classified as relevant. This same test was performed for the leaf extract and partitions of *B. argyrophylla* and the most significant results occurred in the ethyl acetate partition 4.1 ± 0.1 μg.mL^{-1}, followed[39] by the ethanolic extract 4.3 ± 0.8 μg.mL^{-1} and the butanol partition 4.8 ± 0.8 μg.mL^{-1} The best antioxidant activity for the species *B. gardneriana* occurred with the ethyl acetate phase (3.45 ± 0.043 μg.mL^{-1}), followed by the n-butanol phase (3.840 ± 0.005 μg.mL^{-1}) with values similar to or close to the standard substance[49].

Overall, the results obtained for the extracts or partitions analysed have better antioxidant activity values in those with a higher presence of flavonoids and phenolics, directly related to the polarity of the sample. More specifically, there is the possible addition of the synergistic effect promoted by the structure of the catechol group present in the hydroxyl group of the B ring, which can donate hydrogen to stabilize the radical, since the crude ethanolic extracts also had promising results[12,41,49].

In vitro antitumor activity

In a pioneering study[54], substances from the ethyl acetate partition of the hydroethanolic extract of leaves and stems were separated through classic liquid chromatography and tested *in vitro* on B16-F10 melanoma cell line to evaluate their antitumor activity. The partitions were directed towards the class of flavonoids, as it is described in the literature that they contain the ability to inhibit the rapid growth of melanoma, induce apoptosis, and stimulate antitumor immunity in the organism.

Cell proliferation measurement and cytotoxicity for the investigated fractions reduced over 50% of B16-F10 cell viability at a concentration of 125 $\mu g.mL^{-1}$. In contrast, other species widely used as chemotherapeutic agents were unable to reduce 50% of cell viability of different cancer cell lines at doses lower[54] than 125 $\mu g.mL^{-1}$.

Regarding cell migration, it was strongly inhibited, yielding interesting results. It is known that this phenomenon prompts the need for further studies, as such characteristics can lead to the advancement of new strategies and approaches for treating this disease. In this investigation, only one of the fractions generated effects similar to the control, and therefore, was considered irrelevant compared to the others which were able to inhibit the metastatic action of melanoma cells, decrease viability, migration capacity, and cause death of B16-F10 tumor cells[54].

In another study[55], plants had their leaf, stem, and fruit extracts investigated against B16-F10 (mouse melanoma), HepG2 (human hepatocellular carcinoma), K562 (human chronic myelocytic leukemia), and HL-60 (human promyelocytic leukemia) tumor cell lines. The results for the inhibitory effects on growth from extracts/fractions of *B. sericea* make it promising for the development of anticancer drugs, as the values obtained for the ethyl acetate, methanol, and hexane fractions were lower than the reference value inhibitory concentration (IC_{50}) less than 30 $\mu g.mL^{-1}$.

The aqueous extract of acerola fruit (*M. glabra*) was investigated for its effects on melanogenesis in B16 mouse melanoma cells, which significantly reduced cellular melanin levels and inhibited tyrosinase activity in a concentration-dependent manner. It also showed potent antioxidant activity. In human patch tests, no allergic reaction was observed with the presented results. Estimate the possibility[56] that the aqueous extract of the fruit may be part of the composition of anti-aging foods and skin-lightening cosmetics.

Another Malpighiaceae, *Flabellaria paniculata* Cav., was investigated for the treatment and prevention of breast cancer, specifically in West Africa, where traditional practices already involve the use of the roots of this plant. In that study[57], some compounds were isolated and purified from the crude extract and fractions. Among the results, it was observed that *in vitro*, the phytosterols: campesterol glucoside with IC_{50} 1.18 ± 0.18 $mg.mL^{-1}$ and sitosterol with IC_{50} 1.79 ± 0.14 $mg.mL^{-1}$ were more active than the flavonoid quercetin IC_{50} 2.05 ± 0.16 $mg.mL^{-1}$; although the activities are lower when compared to the standard anticancer drug Paclitaxel (IC_{50} 0.07 ± 0.03 $mg.mL^{-1}$). Among the tested fractions on breast cancer cells, the most active was the hexane fraction (0.97 ± 0.05 $mg.mL^{-1}$), followed by the ethyl acetate fraction (2.97 ± 0.19 $mg.mL^{-1}$), aqueous (4.10 ± 0.13 $mg.mL^{-1}$), and butanol (6.22 ± 0.17 $mg.mL^{-1}$).

Potential anti-inflammatory and cytotoxic

The anti-inflammatory and cytotoxic potential, *in vitro*, was also evaluated for the ethyl acetate and dichloromethane fractions of *D. pubipetala* leaves. The extracts were tested for their effects on the production of cytokines IL-6 (interleukin-6), IL-10 (interleukin-10), TNF-α (tumor necrosis factor-α). Additionally, the quantification of nitric oxide levels was performed since it is known to act as a modulator in pathological processes[37].

Cell viability was tested using 3T3 cells (mouse embryonic fibroblast cell lines), and the extracts were found to be cytotoxic. The difference in cell viability between the solvent of the partition was IC_{50} 67.39 $\mu g.mL^{-1}$ for dichloromethane and 103.37 $\mu g.mL^{-1}$ for the ethyl acetate extract. This result indicated that the 3T3 cells were more sensitive to the dichloromethane solvent, suggesting that this partition carries more cytotoxic compounds compared to the ethyl acetate partition[37].

From this MTT (tetrazoline 3-(4,5-dimethylthiazol-2yl)-2,5-diphenyl bromide) assay, it was observed that the pro-inflammatory cytokines IL-6 and TNF-*α* had significantly decreased production in both partitions, with reductions of 45.1% and 40.4% for IL-6, and 35.7% and 32.9% for TNF-*α*, respectively, in the dichloromethane and ethyl acetate partitions[37]. These results are important since the concentrations used for these partitions were lower than the IC_{50} determined in the cytotoxicity tests.

Conversely, in cells treated with these partitions, the levels of the anti-inflammatory cytokine IL-10 were increased, with values of 86.4% for the dichloromethane partition and 78.4% for the ethyl acetate partition compared to the control group.

The production of nitric oxide was particularly increased in 3T3 cells treated with the dichloromethane and ethyl acetate partitions. Using the Griess reaction, values of 291.7% and 316.7% were obtained, respectively, which were higher than the control group (untreated cells). These values, associated with changes in the quantities of pro-inflammatory and anti-inflammatory cytokines, are related to the immunomodulatory capacity promoted by the investigated partitions. This fact is attributed to the presence of flavonoids, which are secondary metabolites that act on the anti-inflammatory response and interfere with the production of cytokines such as TNF-*α*, as well as modulate the enzyme nitric oxide synthase[37,58].

In the same context, when reporting the anti-inflammatory activity in animal models involving the aqueous extract of *B. intermedia* leaves, a potent anti-inflammatory activity was observed with the reduction of paw edema, attributed to the presence of catechin and flavonoids[59]. These substances are essential to produce inflammatory mediators such as cytokines and prostaglandins. In the study involving the butanolic fraction of *B. verbascifolia* leaves, a pronounced anti-inflammatory effect was observed, which may be caused by the inhibition of the release of mediators derived from polymorphonuclear leukocytes[60], TNF-*α*, and prostaglandin E_2.

Flavonoids and phenolic compounds, in general, are attributed with analgesic, antioxidant, and anti-inflammatory functions in extracts from plants of the genus *Byrsonima*. However, studies related to cytotoxicity are scarce, and the results obtained so far imply a high cytotoxic potential. Nevertheless, there has been no investigation into which compounds present in these species would have therapeutic importance. Therefore, chemical characterization can help in understanding the different potentialities of these and other plant species[55,61].

CONCLUSIONS

The research discussed in this review focuses on the chemical aspects, as well as *in*

vitro initiatives related to the action of components present in extracts, partitions, and fractions of leaves and stems of *D. pubipetala* that may act on cancerous and inflammatory processes. Histochemical tests on the leaves, stems and bark showed the presence of flavonoids, alkaloids and terpenes, while in the flowers the presence of lipids in general stood out and, in the seeds, the unsaturated fatty acids stood out.

The literature points out that the varied mineral composition is closely related to other species in the family. Among the metabolites, it is considered that the presence of alkaloids, although not constant, justifies their use in the composition of Ayahuasca tea, which provides benefits in relation to neurodegenerative diseases. Possibly the excellent antioxidant capacity obtained for the leaves and related stems is the quantification of flavonoids and phenolics which are high.

There is still a noticeable lack of studies focusing on the chemical and pharmacological aspects related to the isolation and characterization of secondary metabolites to assess the safety and efficacy of using this species. It was noted other Malpighiaceae species are emerging as potential producers of bioactive compounds, highlighting the need for further research in this area.

Declaration of competing interest

The authors declare that they have no competing financial interests or known personal relationships that could have appeared to influence the work reported in this article.

Acknowledgements

We thank the Graduate Program in Biotechnology - Laboratory of Bioactive Natural Products - State University of Montes Claros - Montes Claros - Brazil, and the Laboratory of Chemistry of Bioactive Natural Products - René Rachou Institute - Oswaldo Cruz Foundation - Belo Horizonte - Brazil. We acknowledge the financial and technological support from FAPEMIG (Process APQ 03057-22).

REFERENCES

1. DAVIS, Charles.C, ANDERSON, William R. A complete generic phylogeny of Malpighiaceae inferred from nucleotide sequence data and morphology. Am. J. Bot.97, 2031-2048,2010. Disponível em: https://doi.org/10.3732/ajb.1000146
2. ALMEIDA, RafaelF., MAMEDE, MariaC.H.,. Checklist, conservation status, and sampling effort analysis of Malpighiaceae in Espírito Santo State, Brazil. Braz. J. Bot. 37, 329–337, 2014. Disponível em: https://doi.org/10.1007/s40415-014-0078-x
3. MAMEDE, Maria.C.H.,. Flora de Grão-mogol, Minas Gerais: Malpiguiaceae. Bol. Bot. Univ. São Paulo.22,291–302.2004. Disponivel em:http://www.jstor.org/stable/42871651
4. ABBAS, Haidy.A, et al. . A Review on Traditional uses, Phytochemistry and Pharmacological Potential of Family Malpighiaceae. Egypt. J. Chem. 65, 235-274,2022. Disponível em: https://doi.org/10.21608/ejchem.2022.119510.5372
5. JOHNSON, O.O., et al. The phytochemistry and pharmacological potentials of Flabellaria paniculata cav. (malpighiaceae): A review of an unexplored medicinal plant. Int. J. Pharmacognosy Life Sci.. 3, 36-41,2022. Disponivel em: https://doi.org/10.33545/27072827.2021.v2.i2a.48
6. GATES, Bronwen. 1982 "Banisteriopsis, Diplopterys (Malpighiaceae)." Flora Neotrop. 30, 1–237.
7. ANDERSON, William R., DAVIS, Charles.C.,. Expansion of Diplopterys at the expense of Banisteriopsis (Malpighiaceae). Harv. Pap. Bot. 11, 1-16, 2006. Disponivel em :https://doi.org/10.3100/1043-4534(2006)95[1:EODATE]2.0.CO;2
8. OLIVEIRA, Regina.C., et al.. Ethnobotany and Wood Anatomy of Banisteriopsis caapi Ethnotaxa and Diplopterys cf. pubipetala, Components of Ayahuasca in Brazilian Rituals. Econ Bot. 77, 18-47, 2023. Disponivel em: https://doi.org/10.1007/s12231-023-09567-w
9. CHRISTENHUSZ, Maarten.J.M., BYNG, James.W., 2016. The number of known plants species in the world and its annual increase. Phytotaxa, 261, 201, 2016. Disponivel em: https://doi.org/10.11646/phytotaxa.261.3.1
10. CARVALHO, Paula.D., RAPINI, Alessandro., CONCEIÇÃO, Abel.A.,. Flora da Bahia: Malpighiaceae - Banisteriopsis, Bronwenia e Diplopterys. SCB. 10. 159-191, 2010. Disponivel em: https://doi.org/10.13102/scb7958.
11. NAGAMINE, Nívia P,et al2021. Vegetative anatomy, morphology and histochemistry of three species of Malpighiaceae used in analogues of the Amazonian psychoactive beverage Ayahuasca. Flora, 275, 151760, 2021. Disponivel em:https://doi.org/10.1016/j.flora.2020.151760
12. SACRAMENTO, Verônica.M., et al,. Chemical profile and antioxidant activity in *Diplopterys pubipetala* (Malpighiaceae). Nat. Prod. Res. 36, 3450-3454., 2020. Disponivel em: https://doi.org/10.1080/14786419.2020.1855644
13. GUIMARÃES, André.L.A., et al . Comparative anatomy and chemical analysis of the vegetative organs of three species of Stigmaphyllon (Malpighiaceae). Flora, 224, 30–41. 2016. Disponivel em: https://doi.org/10.1016/j.flora.2016.07.001

14. POSSOBOM, C.C.F., Guimarães, E., Machado, S.R.. Leaf glands act as nectaries in Diplopterys pubipetala (Malpighiaceae). Plant Biol. 12, 863–870. 2010. Disponivel em: https://doi.org/10.1111/j.1438-8677.2009.00304.x
15. ARAÚJO, Josiane.S., MEIRA, Renata.M.S.A. Comparative anatomy of calyx and foliar glands of Banisteriopsis C. B. Rob. (Malpighiaceae). Acta bot. bras. 30, 112-123. 2016. Disponivel em: https://doi.org/10.1590/0102-33062015abb0248.
16. POSSOBOM, Clivia.C.F., GUIMARÃES, Elza., Machado, Silvia.R. Structure and secretion mechanisms of floral glands in Diplopterys pubipetala (Malpighiaceae), a neotropical species. Flora: Morphol. Distrib. Funct. Ecol. 211, 26-39. 2015. Disponivel em: https://doi.org/10.1016/j.flora.2015.01.002
17. POSSOBOM, Clivia.C.F., MACHADO, Silvia.R. Elaiophores in three Neotropical Malpighiaceae species: a comparative study. Plant Syst. Evol. 304, 15–32. 2017. Disponivel em: https://doi.org/10.1007/s00606-017-1443-6
18. NASCIMENTO, José.J.M., et al. Fenologia e biologia floral de espécies de Byrsonima Rich. ex Kunth em área de caatinga na Bahia, Brasil. Sci Plena. 19, 1-17. 2023. Disponivel em: https://doi.org/10.14808/sci.plena.2023.070201
19. BARÔNIO, Gudryan.J., et al. Characterization of Malpighiaceae flower-visitor interactions in a Brazilian savannah: How do floral resources and visitor abundance change over time. Flora. 234,126-134. 2017. Disponivel em: https://doi.org/10.1016/j.flora.2017.07.015.
20. CAPPELLARI, Simone.C., et all. Pterandra pyroidea: a case of pollination shift within neotropical Malpighiaceae. Ann. Bot. 107, 1323–1334. 2011. Disponivel em:https://doi.org/10.1093/aob/mcr084
21. REIS, Mariza.G., et al. Byrsonic acid—the clue to floral mimicry involving oil-producing flowers and oil-collecting bees. J. Chem. Ecol. 33,1421–1429. 2007. Disponivel em: https://doi.org/10.1007/s10886-007-9309-y.
22. ROSA, Felipe.L., et al. Chemical Characterisation of the Floral Oil of the Murici (Byrsonima sericea): Discovering the Constituents Used in Reproduction by Oil-Collecting Bees. Sociobiol. 6780–88. 2020. Disponivel em: httpss://doi.org/10.13102/sociobiology.v67i1.4432
23. SOUTO, Letícia.S., Oliveira, Denise.M.T. Estrutura do pericarpo de Banisteriopsis CB Rob. e Diplopterys A. Juss.(Malpighiaceae): novos dados suportando a segregação genérica. Acta Bot. Bras., 26, 527-536. 2012. Disponivel em: https://doi.org/10.1590/S0102-33062012000300003
24. SOUTO, Letícia.S., OLIVEIRA, Denise.M.T.. Morfoanatomia e ontogênese das sementes de espécies de Banisteriopsis C.B. Robinson e Diplopterys A. Juss. (Malpighiaceae). Acta Bot. Bras., 22, 733–740. 2008. Disponivel em: https://doi.org/10.1590/S0102-33062008000300011
25. PINHO, R.S., Oliveira, A.F.M., Silva, S. Potential oilseed crops from the semiarid region of northeastern Brazil. Bioresour. Technol. 100, 6114-6117. 2009. Disponivel em: https://doi.org/10.1016/j.biortech.2009.06.010
26. PRAZERES, R.M., et al. Fatty acid profile and physical chemical properties of oil extracted from Banisteriopsis pubipetala (A. Juss.) Cuatrec.(Malpighiaceae) seeds. Period. Tche Quimica. 14, 105-111. 2017. Disponivel em: https://doi.org/10.52571/PTQ.v14.n27.2017.105

27. EGYDIO, Anary.P.M.,. Fatty acid composition of seeds of three Malpighia glabra L. genotypes (Malpighiaceae). Bol. Bot. Univ. São Paulo. 1-4. 2012. Disponivel em: https://doi.org/10.11606/issn.2316-9052.v30i1p5-21
28. JANDACEK, Ronald.J.,. Linoleic Acid: A Nutritional Quandary. Healthcare (Basel). 5. 2017. Disponivel em: https://doi.org/10.3390/healthcare5020025
29. MERCOLA, José., D'ADAMO, Chistopher.R.,. Linoleic Acid: A Narrative Review of the Effects of Increased Intake in the Standard American Diet and Associations with Chronic DiseaseNutrientes. 15. 2023. Disponivel em: https://doi.org/10.3390/nu15143129
30. LOVKOVA, Ya. M, et al. Chemistry of medicinal plants (review). Prikl Biokhim Mikrobiol. 37, 261–73.PMID:11443892. 2001. Disponivel em: https://doi.org/10.1023/A:1010254131166
31. ALMEIDA, Ivone.M.C., et al. Oilseeds from A Brazilian Semi-Arid Region: Edible Potential Regarding the Mineral Composition. Foods. 9, 1-10. 2020. Disponivel em: https://doi.org/10.3390/foods9020229
32. HÄNSCH, Robert., Mendel, Ralf.R.,. Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl). Curr. Opin. Plant Biol. 12, 259–266.2009. Disponivel em: https://doi.org/10.1016/j.pbi.2009.05.006
33. SHREELAKSHMI, S.V., et al. Bioactive compounds and antioxidant activity during ripening of Malpighia glabra fruits. J Food Sci Technol. 2023. Disponivel em: https://doi.org/10.1007/s13197-023-05872-3
34. GUEDES, Tamna.J.F.L, et al. Phytochemical Composition And Antioxidant Potential Of Different Varieties Viz. Flor Branca, Costa Rica And Junco Of Green Unripe Acerola (Malphigia Emarginata D.C.) Fruits. Food Sci. Technol. 42, E46320. 2022. Disponivel em: Https://Doi.Org/10.1590/Fst.46320
35. COSTA, Mariana.O.N., et al. Chemical Composition of Diplopterys pubipetala (Malpighiaceae). European j. med. plants. 31, 43–48. 2020. Disponivel em: https://doi.org/10.9734/ejmp/2020/v31i1530323
36. FRIAS, Ulysses.A., et al. Banisteriopsis Species: A source of bioactive of potential medical application. Int. J. Biotechnol. Wellness Ind. 1, 163-171. 2012. Disponivel em: http://dx.doi.org/10.6000/1927-3037/2012.01.03.02
37. FREITAS, Jeane.F.L., et al. Chromatographic Profiles, Anti-inflammatory, and Cytotoxicity Potential of Extracts of Banisteriopsis pubipetala (A. Juss). Pharmacogn. Res. 11. 339- 345. 2019. Disponivel em : https://doi.org/10.4103/pr.pr_71_19
38. OLIVEIRA, Daiane.M., . Antifungal and cytotoxicity activities of Banisteriopsis argyrophylla leaves. J. Pharm. Pharmacol. 70, 1541–1552. 2018. Disponivel em: https://doi.org/10.1111/jphp.12996
39. QUARESMA, Daiane.M.O., et al. Antioxidant compounds from Banisteriopsis argyrophylla leaves as α-amylase, α-glucosidase, lipase, and glycation inhibitors. *Bioorg. Chem., 105, e104335*. 2020. Disponivel em: https://doi.org/10.1016/j.bioorg.2020.104335
40. ALEXANDRE, Gerson.P., et al. Dereplication by HPLC-ESI-MS and antioxidant activity of phenolic compounds from|Banisteriopsis laevifolia (Malpighiaceae). An. Acad. Bras. Cienc. 94, e20201844. 2022. Disponivel em: https://doi.org/10.1590/0001-3765202220201844.

41. NUNES, Bruno.C., et al . Antimicrobial activity, cytotoxicity and selectivity index of Banisteriopsis laevifolia (A. Juss.) B. Gates leaves. Ind Crops Prod. 92, 277-289. 2016 https://doi.org/10.1016/j.indcrop.2016.08.016
42. GUILHON,Simplicio. F, et al . Antioxidant activity of a standardized extract of Byrsonima japurensis A. Juss.(Malpighiaceae) stem bark. J Med Plants Res, v. 7, p. 1926-1930, 2013. Disponivel em: 10.5897/JMPR12.1133
43. MCKENNA, Dennis.J,. Clinical investigations of the therapeutic potential of ayahuasca: rationale and regulatory challenges. Pharmacol Ther. 102, 111-129. 2004. Disponivel em:https://doi.org/10.1016/j.pharmthera.2004.03.002
44. SAMOYLENKO, Volodymyr., et al. Banisteriopsis caapi, a unique combination of MAO inhibitory and antioxidative constituents for the activities relevant to neurodegenerative disorders and Parkinson's disease. J. Ethnopharmacol. 127, 357–367. 2010. Disponivel em: https://doi.org/10.1016/j.jep.2009.10.030
45. GONÇALVES, Joana., et al . A Systematic Review on the Therapeutic Effects of Ayahuasca. Plants (Basel). 12, 1-25. 2023. Disponivel em: https://doi.org/10.3390/plants12132573
46. MAIA, Lucas.O., et al. Ayahuasca's therapeutic potential: What we know–and what not. Eur Neuropsychopharmacol. 66, 45-61. 2023. Disponivel em: https://doi.org/10.1016/j.euroneuro.2022.10.008
47. PERKINS, Daniel, et al . Psychotherapeutic and neurobiological processes associated with ayahuasca: A proposed model and implications for therapeutic use. Front. Neurosci. 16, e879221. 2023. Disponivel em: https://doi.org/10.3389/fnins.2022.879221
48. SANTOS, Beatriz.W.L., et al . Biodiversity of β-Carboline Profile of *Banisteriopsis caapi* and Ayahuasca, a Plant and a Brew with Neuropharmacological Potential. *Plants*. *9*, 870. 2020. Disponivel em:https://doi.org/10.3390/plants9070870
49. ROLIM, Thaísa.L., et al, .Chemical constituents and antioxidant activity of Byrsonima gardneriana (Malpighiaceae). Quim. Nova. 36, 524-527. 2013 https://doi.org/10.1590/S0100-40422013000400007.
50. ROYO, V.A., Araújo, B.C.P., Barros, B.P.,. Métodos fitoquímicos para identificação de metabólitos secundários. Novas Edições Acadêmicas. Minas Gerais. 2015
51. SACRAMENTO, V.M., Veloso, P.H.F., Royo, V.A., Abreu, N.S., Souto, K.S.F., Júnior, A.F.M., 2023. Métodos para determinação de capacidade antioxidante. Atenas, Minas Gerais
52. VASCONCELOS, Thiago.B., et al . Radicais Livres e Antioxidantes: Proteção ou Perigo?. UNOPAR Cient Ciênc Biol Saúde. 16. 2014. Disponivel em: https://doi.org/10.17921/2447-8938.2014v16n3p%25p
53. HOSSEN, Sakib., et al . Beneficial roles of honey polyphenols against some human degenerative diseases: A review. Pharmacol Rep. 69, 1194–1205, 2017 Disponivel em : https://doi.org/10.1016/j.pharep.2017.07.002
54. SANTOS, Kamylla.T., et al.. *In vitro* Antitumor Effect on Melanoma Cell Line and Chemical Composition of *Diplopterys pubipetala* (A. Juss) W.R. Anderson and C. Davis. Pharmacog Rev. 14, 146-154, 2020. Disponivel em: https://doi.org/10.5530/phrev.2020.14.18

55. SILVA, Thiago.B.C., et al, . Cytotoxic potential of selected medicinal plants in Northeastern Brazil. BMC Altern Med Complement.16, 199, 2016 Disponivel em : https://doi.org/10.1186/s12906-016-1166-1
56. WANG, Ling W, et al, . Antioxidant activity and melanogenesis inhibitory effect of acerola fruit (Malpighia glabra L.) aqueous extract and its safe use in cosmetics. Asian J. Chem..27, 957-960, 2015. Disponivel em: http://www.asianjournalofchemistry.co.in/user/journal/viewarticle.aspx?ArticleID=27_3_32
57. JOHNSON, Oluwatosin.O., et al..Compounds isolated from the roots of flabellaria paniculata cav. (Malpighiaceae) and their effects on mcf-7 breast cancer cells. Trop. J. Nat. Prod. Res. 4, 1033-1038, 2020 Disponivel em: doi.org/10.26538/tjnpr/v4i12.2
58. ZHANG, Z., et al.. Ethyl acetate fraction from Nymphaea hybrida Peck modulates inflammatory responses in LPS-stimulated RAW 264.7 cells and acute inflammation murine models. J. Ethnopharmacol. 269, 1-12, 2021. Disponivel em: https://doi.org/10.1016/j.jep.2020.113698
59. MOREIRA, Lucimara.Q, et al. Anti-inflammatory effect of extract and fractions from the leaves of Byrsonima intermedia A. Juss in rats J Ethnolopharmacol. 138,610–615, 2011. Disponivel em: https://doi.org/10.1016/j.jep.2011.10.006
60. SALDANHA, Aline.A., et al. Anti-inflammatory effects of the butanolic fraction of Byrsonima verbascifolia leaves: Mechanisms involving inhibition of tumor necrosis factor alpha, prostaglandin E(2) production and migration of polymorphonuclear leucocyte in vivo experimentation. Int. Immunopharmacol. 31, 123–131, 2016. Disponivel em: https://doi.org/10.1016/j.intimp.2015.12.031
61. SILVA, Iago.K.S.P., et al..Chemical studies and pharmacological activities of species belonging to the genus Byrsonima: an integrative review. Research, Society and Development . 2, e5411220972, 2022. Disponivel em: https://doi.org/10.33448/rsd-v11i2.20972.