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Miconia albicans (Sw.) Triana (canela-de-velho), the new trend plant from the Brazilian Cerrado: contribution to species identification and pharmacological aspects

Diego Tavares Iglesias[1]; Rúbia Santos Fonseca[2]*

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Abstract

Miconia albicans (canela-de-velho) is a species widely distributed in the Cerrado. In recent years, its leaves have been commercialized for the preparation of medicinal teas. The genus *Miconia* is highly diverse in the Cerrado, and the high morphological similarity of the species often results in misidentification, even by specialists. The aim of this paper is to contribute to the identification of *M. albicans*, and its distinction from other Cerrado species with morphological similarity. In addition, a literature review of the species was performed in search of studies on potential biological and pharmacological activity. Nineteen samples of plants marketed as "canela-de-velho" and/or *Miconia albicans* were acquired from fairs in six municipalities in Minas Gerais, Brazil. The species were properly identified and conflicting characters were determined. Based on these characters, a survey of all species with morphological similarity in Cerrado was carried out. Thirteen species similar to *M. albicans* were found, and an illustrated identification key was developed. As for the review of biological activity, only *M. albicans* presents anti-inflammatory activity identified by one study. *M. albicans* and six of the 13 identified species showed cytotoxicity at high concentration levels in studies with *in vitro* and *in vivo* analyses. *M. albicans* accumulates aluminum in the leaves, which are the organs used to prepare the infusion. Currently, there are no clinical trials to validate the use of *M. albicans* as herbal medicine. Indiscriminate use and lack of scientific evidence, besides not producing the desired results, can cause adverse effects.

Keywords: Medicinal plant. Phytotherapy. Taxonomy. Melastomataceae.

Miconia albicans (Sw.) Triana (canela-de-velho), a nova planta tendência do Cerrado brasileiro: contribuição para identificação de espécies e aspectos farmacológicos

Resumo

Miconia albicans (canela-de-velho) é uma espécie amplamente distribuída no Cerrado. Nos últimos anos suas folhas têm sido amplamente comercializadas para o preparo de chás medicinais. O gênero *Miconia* apresenta alta diversidade no Cerrado. A elevada similaridade morfológica entre essas espécies promove erros de identificação, inclusive por especialistas. O objetivo do trabalho é contribuir para o reconhecimento da espécie *Miconia albicans* e a sua distinção de outras espécies similares do Cerrado. Além disso, foi realizada revisão de literatura sobre a atividade biológica das espécies com similaridade morfológica. Foram adquiridas 19 amostras de plantas comercializadas como "canela-de--velho" e/ou *Miconia albicans* em feiras de seis municípios de Minas Gerais, Brasil. As espécies foram devidamente identificadas e os caracteres conflituosos foram determinados. A partir desses caracteres foi realizado o levantamento de todas as espécies com similaridade morfológica no Cerrado. Foram encontradas 13 espécies similares a *M. albicans*; uma chave ilustrada de identificação foi elaborada. Apenas *M. albicans* apresenta atividade anti-inflamatória indicada por um estudo. *M. albicans* e seis das 13 espécies similares, apresentaram citotoxicidade a níveis de concentração elevados, em análises *in vitro* e/ou *in vivo*. Estudos demonstraram que *M. albicans* acumula alumínio em suas folhas, órgãos usados para o preparo das infusões. Inexistem ensaios clínicos para validar o uso dessa espécie como fitoterá-

[1]Universidade Federal de Minas Gerais. Montes Claros, MG. Brasil.
https://orcid.org/0000-0002-9160-9959
[2]Universidade Federal de Minas Gerais. Montes Claros, MG. Brasil.
https://orcid.org/0000-0001-7257-874X
*Autor para correspondência: rubiafonseca@hotmail.com

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pico. O uso indiscriminado, associado à carência de provas científicas, além de não produzir os resultados desejados, pode causar efeitos adversos.

Palavras-chave: Planta medicinal. Fitoterapia. Taxonomia. Melastomataceae.

Introduction

Brazil has the largest plant diversity on the planet (Forzza et al., 2012). An important part of' this biodiversity is in the Cerrado, which accounts for 23% of the country's area, occurring in all geographic regions except the south (IBGE, 2004). This savanna is the richest in the world and one of the priority areas for conservation (Myers et al., 2000). The cerrado has been historically managed by its peoples due to the abundance of food species, especially fruit and medicinal plants, which provided support to traditional extractive activities (Dias and Laureano, 2010).

Melastomataceae is among the main plant families of the Cerrado, with about 500 species (BFG, 2015). *Miconia* Ruiz & Pav. is the richest genus of this family, with 67 species in the Cerrado (BFG, 2015). A large number of species of *Miconia* are traditionally used for different medicinal purposes (Serpeloni et al., 2011, Andrade e Silva, 2002). However, this genus includes many morphologically similar species and, therefore, they are often misidentified (Rezende et al., 2014; Caddah and Goldenberg, 2013).

Misrecognition of species is one of the main problems faced by ethnobotanists (Luczaj 2010), as the adulteration of species with therapeutic use is common in retail shops and street markets (Coulaud-Cunha et al., 2004). For example, "espinheira-santa" (*Maytenus ilicifolia* Mart. Ex. Reiss - Celastraceae), a species used in the relief of rheumatism, is commonly replaced by the morphologically related *Sorocea bomplandii* Bailon (Moraceae), but with unknown toxicity (Coulaud-Cunha et al., 2004). Adulteration of medicinal plants is often related to periods of increased demand for the species (Coulaud-Cunha et al., 2004; Mitra and Kannan, 2007, Posadzki et al., 2013). Market demand for a medicinal species varies temporally in response to many factors, including consumption fads (Bussmann and Sharon, 2006).

Miconia albicans (Sw.) Triana is the trend medicinal plant in the Brazilian cerrado. This species is widely distributed in Brazil, mainly in open Cerrado formations (Meirelles, 2015). Popularly known as "canela-de-velho" (old man's shin), the leaf infusion of *M. albicans* has been widely used by cerrado communities to relief digestive disturbances and mainly rheumatism (Cruz and Kaplan, 2004; Seperloni et al., 2011). However, the use of *M. albicans* has not yet been regulated (ANVISA, 2016), since the steep growth of interest is recent and studies on the species are still in the early stages. Therefore, the sale of the medicine called "canela-de-velho" has been banned in Brazil (Ministério da Saúde, 2018). However, "canela-de-velho" is easily found commercially in crude form or as by-products. This study aims to contribute to the recognition of *M. albicans* and its distinction from morphologically related species in the Cerrado domain, providing identification keys, diagnoses, illustrations, and we propose new research directions for *M. albicans*.

Material and methods

The species morphologically related to *M. albicans*, occurring in the Cerrado, were selected from three steps. Step one: Samples of leaves and branches marketed as "canela-de-velho" and/or *Miconia albicans* were purchased in the following municipalities of Minas Gerais located near Cerrado areas: Belo Horizonte (10), Bocaiúva (1), Diamantina (1), Jaíba (1), Januária (1), and Montes Claros (5). From the analysis of these samples, four distinct species were recognized: *M. albicans* (11), *M. macrothyrsa* (4), *M. rubiginosa* (3), and *M. cinerascens* (1). We did not find mixture of species within the same sample.

Step two: The botanical descriptions of these species were compared to that of *M. albicans* and the conflicting characteristics were identified. The characteristics included: habit - schrubs or small trees; leaves - oval, oblong, elliptic, or oboval, strongly bicolored (adaxial surface green, abaxial surface canescent, ocher or rusty), usually smaller than 15 cm long, and dense indument in the abaxial leaf surface and on young branches. Step three: The presence of the set of conflict characteristicistics was investigated in all species of the genus occurring in Cerrado *sensu lato,* using the database BFG (2019).

To construct the identification keys, we use the diagnostic characteristics from species descriptions in floristic-taxonomic studies conducted locally and in other cities of the state, taxonomic reviews, princeps works (Candido, 2005; Cogniaux, 1887/1888; Rezende et al., 2014; Martins et al., 1996; Meirelles, 2015, Meirelles et al., 2016), and analysis of voucher specimens authenticated by specialists. The biological activity of these species was reviewed using six electronic databases without a time frame: Pubmed, SciFinder, Web of Science, Science Direct, SciELO, and Google Scholar. The key term used in the search was the species scientific name.

Results and discussion

Characterization and identification of morphologically related species

Thirteen species morphologically related to *Miconia albicans* were determined for the Cerrado *sensu lato*: *Miconia alborufescens* Naudin, *M. astrocalyx* Meirelles & R.Goldenb., *M. burchellii* Triana, *M. cinerascens* Miq., *M. fallax* DC., *M. herpetica* DC., *M. hyemalis* A.St.-Hil. & Naudin, *M. leucocarpa* DC., *M. macrothyrsa* Benth., *M. rubiginosa* (Bonpl.) DC., *M. sclerophylla* Triana, *M. stenostachya* DC and *Miconia weddelli* Naudin. Among this species, M. *alborufescens*, *M. astrocalyx*, *M. fallax*, *M. herpetica*, and *M. stenostachya* belong to the same clade as *Miconia albicans*, suggesting phylogenetic proximity (Meirelles, 2015). *M. fallax* and *M. stenostachya* have been described as very similar to *M. albicans* in the Cerrado, leading to conflicts in the identification (Rezende et al., 2014). Studies have shown that *M. albicans* exhibits large variation in leaf size and plant architecture between different habitats (Silveira and Oliveira, 2013). This phenotypic plasticity, added to the morphological similarity with other species, causes even more conflicts in its identification.

Miconia albicans and most morphologically related species are often associated to secondary vegetation and commonly found in borders and disturbed areas (Araújo and Romero, 2016; Goldenberg, 2004; Saporetti Jr., 2003). In a similar manner, this group has a preference for acid soils which explains its frequency in dystrophic and nutrient-poor soils of the Cerrado (Haridasan and Araújo, 1988). Ethnobotanical studies indicate that traditional communities prioritize areas with anthropogenic disturbance for the collection of medicinal plants (Gavin, 2009; Stepp and Moerman, 2001; Voeks, 2004). Consequently, the distribution pattern of *Miconia* species favors high indiscriminate extractivism of co-current species.

The World Health Organization proposes the valuation and conservation of biodiversity, in association with studies that integrate products, practices, and practitioners (WHO, 2013). Although it is not the focus of this study, the adulteration of *M. albicans* samples with three other morphologically related species (*M. macrothyrsa*, *M. rubiginosa,* and *M. cinerascens*) was confirmed. Adulteration is defined as a fraudulent act of partially or totally replace the herbal product with another product (Posadzki et al., 2013). This practice is common in plant commodity trade (Mitra and Kannan, 2007). However, it is often unintentional and related to lack of knowledge about the plants and similarity in morphology and aroma of the species (Mitra and Kannan, 2007). Adulteration, besides causing economic damage to consumer, can result in serious health problems due to the ingestion of non-indicated species. Thus, there is a need to develop methods to support research on ethnopharmacology and ethnobiology, considering the diversity and endemisms of the Brazilian flora (Albuquerque and Hanazaki, 2006). To avoid misidentification of the species of interest, we constructed an identification key to diagnose species morphologically related to *Miconia albicans* from the Cerrado *sensu lato*.

Identification key for *Miconia albicans* and morphologically related species.

1. Inflorescence with scorpioid distal branches (Fig.1a).

  2. Sessile to subsessile leaves (Fig. 1b) .... 6. *Miconia fallax*

  2. Petiolate leaves.

    3. Leaf margin ciliate (Fig. 1c) .... 10. *Miconia macrothyrsa*

    3. Leaf margin eciliate.

      4. Abaxial surface with dendritic or stellate trichomes (Fig. 1d-e).

        5. Abaxial surface whitish .... 14. *Miconia weddellii*

        5. Abaxial surface yellowish.

          6. Petal margins with glandular-stipitate trichomes, fruit with persistent calyx lobes .... 3. *Miconia astrocalyx*

          6. Petals glabrous, fruit with deciduous calyx lobes .... 7. *Miconia herpetica*

      4. Abaxial surface with amorphous or arachnoid trichomes (Fig. 1f).

        7. Branches with stellate trichomes, Petal margins ciliate .... 13. *Miconia stenostachya*

7. Branches with arachnoid trichomes, Petal margins eciliate ....1. *Miconia albicans*

1. Inflorescence with non-scorpioid distal branches.

8. Panicle with glomerular distal branches (Fig. 1g).

9. Branches with stellate trichomes (Fig. 1e).

10. Leaf base cordate (Fig. 1h) ....2. *Miconia alborufescens*

10. Leaf base rounded or attenuate (Fig. 1i-j) ....5. *Miconia cinerascens*

9. Branches with stellate and dendritic trichomes (Fig. 1d-e).

11. Abaxial surface with dendritic indument. (Fig. 1d) ....12. *Miconia sclerophylla*

11. Abaxial surface with stellate or dendritic-stellate indument (Fig. 1d-e).

12. Abaxial surface with stellate indument (Fig. 1e).

13. Connective with ventral auricules (Fig. 1k) ....9. *Miconia leucocarpa*

13. Connective without ventral auricules ....4. *Miconia burchellii*

12. Abaxial surface with dendritic-stellate indument (Fig. 1d-e).

14. Leaf abaxial surface completely covered by indument, epiderm visible... ....9. *Miconia leucocarpa*

14. Leaf abaxial surface sparsely to moderately covered by indument, epiderm non-visible ....8. *Miconia hyemalis*

8. Panicle with non-glomerular distal branches ....11. *Miconia rubiginosa*

1. *Miconia albicans* (Sw.) Triana, Trans. Linn. Soc. London. 28: 116, 1871.

Based on the descriptions of Cogniaux (1887/1888), Martins (1996), and Meirelles (2015), the following are the diagnostic characteristics of the species:

Branches and leaf abaxial surface with indument whitish and trichomes arachnoid. Branches cylindrical. Leaves Petiolate; Blade oblong to ovate, margin entire to slightly serrate in the upper third, ciliate; one pair of lateral nerves, with a faint additional marginal pair. Inflorescence with scorpioid distal branches. Petals Glabrous. Fruit unripe red; fruit ripe jade green.

It is possible to differentiate *Miconia albicans* only using the vegetative characteristics described, making it practical to identify it. However, to differentiate the other species from each other will require the reproductive characteristics listed in the identification key.

2. *Miconia alborufescens* Naudin, Ann. Sci. Nat., Bot. to be. 3.16: 160. 1850.

It differs from *M. albicans* in the shape of the limb cordate (vs. oblong to oval), two pairs of lateral ribs (vs. one pair of lateral ribs), and a less obvious marginal pair, usually inflorescence glomerulus panicle (vs. scorpioid panicle), fruit ripe red (vs. jade green) (Cogniaux, 1887/1888; Meirelles, 2015).

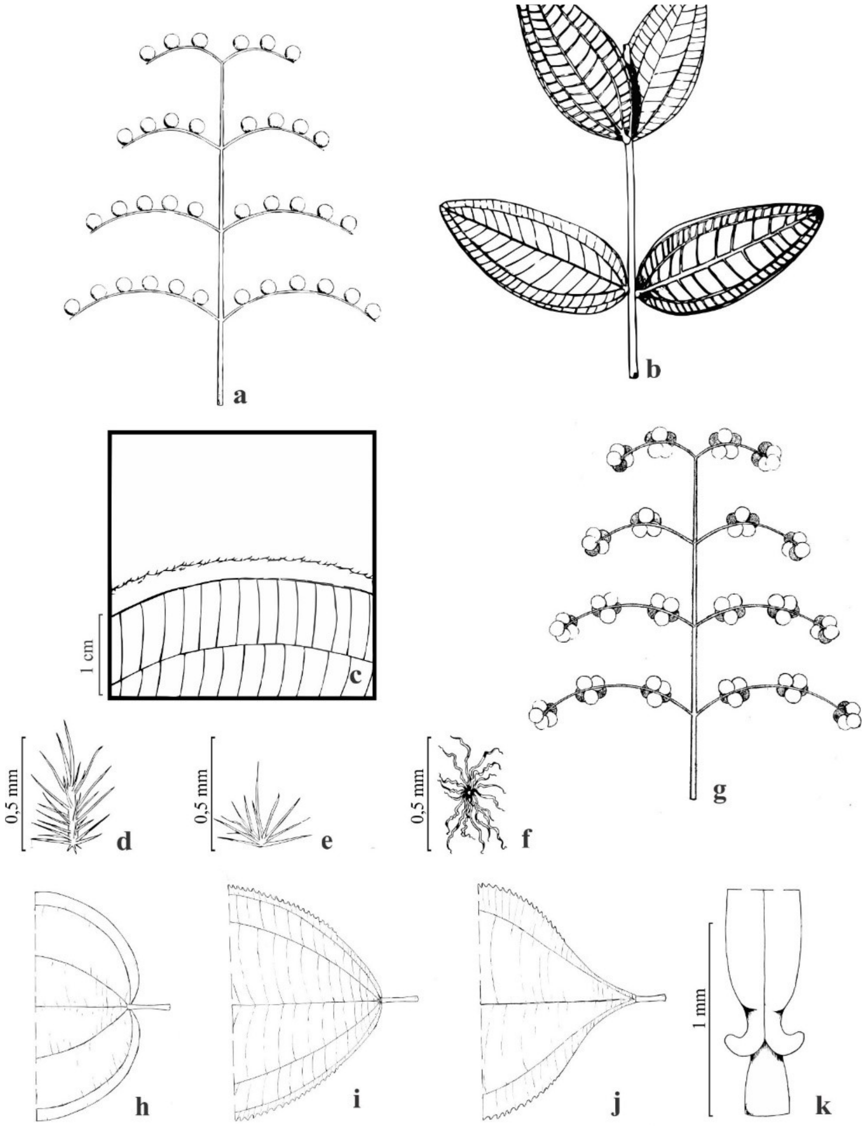
3. *Myconia astrocalyx* Meirelles & R.Goldenb., Phytotaxa 257: 188. 2016.

It differs from *M. albicans* by its indument rusty--yellow (vs. canescent) on the branches and abaxial leaf surface, consisting of stellate trichomes (vs. arachnoid) (Meirelles et al., 2016).

4. *Miconia burchellii* Triana, Trans. Linn. Soc. London 28: 116, 1871.

It differs from *M. albicans* by its branches generally tetragonal (vs. cylindrical), trichomes stellate or dendritic (vs. arachnoid), inflorescence glomerulus panicle (vs. scorpioid panicle) (Cogniaux, 1887/1888).

Figure 1-a – Inflorescence with scorpioid distal branches. b. Leaves sessile. c. Leaf margin ciliate. d. Dendritic trichome. e. Stellate trichome. f. Arachnoid trichome. g. Panicle with glomerular distal branches. h. Leaf base cordate. i. Leaf base rounded. j. Leaf base attenuate. k. Connective with ventral auricules.



5. ***Miconia cinerascens*** Miq., Linnaea 22: 543, 1849.

It differs from *M. albicans* by trichomes stellate (vs. arachnidoid), leaf margin dentate, except at the base (vs. whole or slightly serrated at the top), inflorescence glomerulus panicle (vs. scorpioid) (Cogniaux, 1887/1888; Martins, 1996).

6. *Miconia fallax* DC., Prodr. 3: 181, 1828.

It differs from *M. albicans* in its leaves sessile to subsessile (vs. distinctly petiolate), petals ciliate to glandular (vs. glabrous), ripe fruit black (vs. jade green) (Martins, 1996).

7. *Miconia herpetica* DC., Prodr. 3: 181, 1828.

It differs from *M. albicans* by its indument yellow to rusty-yellow (vs. canescent), trichomes stellate or dendritic (vs. arachnoid) (Rezende, 2014; Meirelles, 2015).

8. *Miconia hyemalis* A.St.-Hil. & Naudin, Ann. Sci. Nat., Bot. to be. 3.16: 142. 1851.

It differs from *M. albicans* by the indument dendritic-stellate (*vs*. arachnoid), leaf margin dentate (*vs*. entire or slightly serrated at the top), inflorescence glomerulus panicle (*vs*. scorpioid panicle) (Martins, 1996).

9. *Miconia leucocarpa* DC., Prodr. 3: 182. 1828.

It differs from *M. albicans* by branches with indument ocher-rusty (*vs*. canescent), trichomes stellate or dendritic (*vs*. arachnoid), inflorescence glomerulus panicle (*vs*. scorpioid) (Martins, 1996; Rezende, 2014).

10. *Miconia macrothyrsa* Benth., J. Bot. (Hooker) 2: 312. 1840.

It differs from *M. albicans* by indument rusty (*vs*. canescent), trichomes stellate (*vs*. arachnoid), leaf lobe generally broadly elliptic to suborbicular (*vs*. oval to oblong), leaf margin serrate-ciliate (*vs*. non-ciliate) (Martins, 1996).

11. *Miconia rubiginosa* (Bonpl.) DC., Prodr. 3: 183, 1828.

It differs from *M. albicans* by its indument rusty (vs. canescent), trichomes stellate (vs. arachnoid), inflorescence non-scorpioid panicle (vs. scorpioid) (Martins, 1996; Rezende, 2014).

12. *Miconia sclerophylla* Triana, Trans. Linn. Soc. London 28 (1): 119, 1871.

It differs from *M. albicans* by its trichomes dendritic (vs. arachnoid), inflorescence glomerulus panicle (vs. scorpioid) (Candido, 2005).

13. *Miconia stenostachya* DC. Prodr. 3: 181, 1828.

It differs from *M. albicans* by its branches tetragonal (vs. cylindrical), trichomes stellate (vs. arachnoid), petals ciliate to glandular (vs. glabrous) (Martins, 1996; Meirelles, 2015).

14. *Miconia weddelli* Naudin, Ann. Sci. Nat. Bot. Ser. 3, 16: 144, 1850.

It differs from *M. albicans* by its trichomes stellate (vs. arachnoid), petals glandular-ciliate (vs. glabrous) (Meirelles, 2015).

Pharmacological aspects of *Miconia albicans* and morphologically related species

Due to the wide area of occurrence of *M. albicans*, its common names and popular uses vary. In Rio de Janeiro, ethnobotanical studies report its vernacular (common) name as a “abranda-fogo” (fire softener) and leaves are used for bath preparation (Maioli-Azevedo and Fonseca-Kruel, 2007). In Espirito Santo, it is called “camará-mirim” (small camará) and is used for fruit consumption and firewood (Crepaldi and Peixoto, 2010). In Mexico, it is used for oral inflammations and is called by the indigenous name “pak tesua” (Leonti et al., 2001). In states where the cerrado occurs, *M. albicans* is better known as “canela-de-velho” and is consumed as tea (infusion) (Lisboa et al., 2017; Almeida et al., 2014). The vernacular “canela-de-velho” has received widespread digital media advertising and tutor videos, some of which clearly misidentify the plant material presented.

The biological activity and pharmacological potential was studied in only four of the 13 morphologically related species of the cerrado: *M. albicans*, *M. fallax*, *M. rubiginosa*, and *M. stenostachya* (Table 1), however, without clinical tests. The anticlastogenic, antimutagenic, and antinociceptive activities of *M. albicans* were shared with the other species, while the antioxidant and inflammatory activities were restricted to *M. albicans*. The anti-inflammatory activity may be related to its popular use in the treatment of musculoskeletal pain caused by diseases traditionally known as “rheumatism” (Cruz and Kaplan, 2004).

The qualitative chemical analysis of the extracts of *M. albicans*, *M. rubiginosa*, and *M. stenostachya* showed similar composition, containing mainly flavonoids, phenolic compounds, and tannins (Serpeloni, 2008). Studies of the three species, *M. albicans*, *M. cabucu*, and *M. stenostachya,* were carried out using *in vivo* (Serpeloni, 2008) and *in vitro* (Serpeloni, 2011) analyses. Serpeloni (2011) found that, at high concentrations, the extracts presented cytotoxic activity in the *in vitro* tests, with *M. albicans* at the lowest concentration (30 μg/mL) and *M. stenostachya* at the highest concentration (60 μg/mL). Neither species showed mutagenic activity in both tests (Serpeloni, 2008; 2011), but the *in vivo* tests showed moderate genotoxic activity (Serpeloni, 2008). Phytochemical and toxicity variations between different plant species create a high risk for their use in popular medicine (Bochner et al., 2012). These studies demonstrate the potential and lack of information about *Miconia* species, prompting further research regarding the pharmacological viability of these species and safe intake concentrations. It is of note that prior to any pharmacological evaluation, the certification of the species identity must be prioritized.

An important characteristicistic of Melastomataceae that must be evaluated for human consumption is the aluminum accumulation capacity. The ability is common in some plant groups such as the genus *Miconia*, occurring in 82% of the species evaluated (Jansen et al., 2002). *M. albicans* has a high concentration of aluminum in fruits (Pasta et al., 2019) and leaves (Haridasan and Araújo, 1988), which is the part used for the preparation of infusions (Lisboa et al., 2017). The presence of aluminum (Al) in teas has been related to acidic soils where the plants occur (Karak and Bhagat, 2010). Currently, aluminum is known to be an accelerating factor of brain aging and may contribute to the development of Alzheimer’s disease (Bondy, 2016). However, in other species, the preparation of the infusion reduces the amount of aluminum to be consumed in comparison with fresh leaf, reducing the health risk (Li et al., 2015). Because of the high consumption of *M. albicans*, research is urgently needed to perform pharmacological, toxicological, and clinical trials with the infusion to ensure the safety of its consumption.

Table 1 – Biological activity of species morphologically related to *Miconia albicans* (Sw.) Triana in Cerrado *sensu lato*.

Biological activity	Species	References
Anticarcinogenic	*Miconia fallax*	Furtado et al., 2008
Anticlastogenic	*Miconia albicans*, *Miconia rubiginosa*, *Miconia stenostachya*	Serpeloni et al., 2008
Antiinflammatory	*Miconia albicans*	Vasconcelos et al., 2006
Antimicrobial	*Miconia albicans*, *Miconia fallax*, *Miconia rubiginosa*	Rodrigues et al., 2008; Celotto et al. 2003
Antimutagenic	*Miconia albicans*, *Miconia rubiginosa*, *Miconia stenostachya*	Serpeloni et al., 2011
Antinociceptive	*Miconia albicans*, *Miconia fallax*, *Miconia rubiginosa*	Vasconcelos et al., 2006; Silva et al., 2002; Spessoto et al., 2003
Antioxidant	*Miconia albicans*	Pieroni et al., 2011
Trypanocidal	*Miconia fallax*, *Miconia stenostachya*	Cunha et al., 2003

Conclusion

Miconia albicans is the most popular medicinal plant in the cerrado. The species is used as infusion for the relief of rheumatism. In the Cerrado *sensu lato*, 12 species are morphologically related with *Miconia albicans* (canela-de-velho) with potential for misidentification due to the similarity of growth habit and bicolored leaves. *Miconia albicans* is distinguished by the arachnoid-canescent indument in the leaves and the cylindrical branches. Other characteristics such as scorpioid inflorescence, unripe red and ripe jade green fruits are also important for accurate species identification. Analysis of commercially available canela-de-velho samples indicates the presence of three other similar species, confirming adulteration due to misidentification. The identification key associated with diagnostic information allows the recognition of this species and correlates in the Cerrado *sensu lato*. Preliminary information regarding the composition and biological activity of the leaf extract suggests that variations in the quantity of the components may change their biological activity. *M. albicans* has anti-inflammatory biological activity, but there are no clinical tests to validate its pharmacological use. *M. albicans* accumulates aluminum in the leaves, which are the organs used to prepare the infusion. Because of the potential toxic effect of aluminum and the lack of information about its concentration in infusions, studies in this line are urgent and of great public health.

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