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Combretum leprosum Mart.: Botany, Ethnomedicinal Uses, Biological Activities, Phytochemistry and Conservation Needs

Combretum leprosum Mart.: Botânica, Usos Etnomedicinais, Atividades Biológicas, Fitoquímica e Necessidades de Conservação

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Abstract

Combretum leprosum is a plant species with wide distribution in Brazil known as "mofumbo", standing out in studies associated with its pharmacological and ethnobotanical activity. The medicinal applications of the species are widely reported in the literature, using the bark, leaves and flowers as healing agents. Given the economic, pharmacological and ecological importance, this work aimed to present a systematic review of production, conservation status and knowledge about the species in different fields of knowledge. The literature review was based on seven categories, characterized according to the study area: biological and/or pharmacological activity (32 articles), importance of conservation status (29), botanical aspects (18), phytochemistry (9), geographic distribution (8), foraging (5) and ethnobotanical uses (2). Most of the works address biological and/or pharmacological activity of the species, and its

application is focused on antitumor action, treatment against Chagas disease, antinociceptive behavior, antibacterial, antioxidant, anti-inflammatory and antiproliferative action. Among the compounds isolated from *C. leprosum* with different applications, 3*β*-6*β*-16*β*-trihydroxylup-20(29)-ene stands out, a lupane triterpene isolated from different parts of the plant, associated with different medicinal and therapeutic applications. The species was highlighted in works associated with environmental regeneration, being resistant to different phytophysiognomies and showing tolerance to environments contaminated by heavy metals, being able to represent an important species in reforestation programs and recovery of degraded environments. However, even with the growing number of studies associated with *C. leprosum* in recent years, the species does not have an assessment regarding its degree of threat, demonstrating the need for research associated with the species and the possible impacts that its representatives may suffer, helping in sustainable development and conservation programs.
Keywords: Biological activity; Caatinga; Combretaceae; Conservation; Semiarid.

Resumo

Combretum leprosum é uma espécie vegetal com ampla distribuição no Brasil conhecida como "mofumbo", destacando-se em estudos associados à sua atividade farmacológica e etnobotânica. As aplicações medicinais da espécie são amplamente relatadas na literatura, utilizando a casca, folhas e flores como agentes curativos. Dada a importância econômica, farmacológica e ecológica, este trabalho teve como objetivo apresentar uma revisão sistemática da produção, estado de conservação e conhecimento sobre a espécie em diferentes áreas do conhecimento. A revisão da literatura foi baseada em sete categorias, caracterizadas de acordo com a área de estudo: atividade biológica e/ou farmacológica (32 artigos), importância do estado de conservação (29), aspectos botânicos (18), fitoquímica (9), distribuição geográfica (8), forrageamento (5) e usos etnobotânicos (2). A maioria dos trabalhos aborda a atividade biológica e/ou farmacológica da espécie, e sua aplicação está focada na ação antitumoral, tratamento contra a doença de Chagas, comportamento antinociceptivo, ação antibacteriana, antioxidante, anti-inflamatória e antiproliferativa. Dentre os compostos isolados de *C. leprosum* com diferentes aplicações, destaca-se o 3*β*-6*β*-16*β*-trihidroxilup-20(29)-eno, um triterpeno de lupano isolado de diferentes partes da planta, associado a diferentes aplicações medicinais e terapêuticas. A espécie foi destaque em trabalhos associados à regeneração ambiental, sendo resistente a diferentes fitofisionomias e apresentando tolerância a ambientes contaminados por metais pesados, podendo representar uma espécie importante em programas de reflorestamento e recuperação de ambientes degradados. No entanto, mesmo com o crescente número de estudos associados ao *C. leprosum* nos últimos anos, a espécie não possui uma avaliação quanto ao seu grau de ameaça, demonstrando a necessidade de pesquisas associadas à espécie e os possíveis impactos que seus representantes podem sofrer, ajudar em programas de desenvolvimento sustentável e conservação.
Palavras-chave: Atividade biológica; Caatinga; Conservação; Combretaceae; Semiárido.

Resumen

Combretum leprosum es una especie vegetal de amplia distribución en Brasil conocida como "mofumbo", destacándose en estudios asociados a su actividad farmacológica y etnobotánica. Las aplicaciones medicinales de la especie están ampliamente reportadas en la literatura, utilizando la corteza, hojas y flores como agentes curativos. Dada la importancia económica, farmacológica y ecológica, este trabajo tuvo como objetivo presentar una revisión sistemática de la producción, el estado de conservación y el conocimiento sobre la especie en diferentes campos del saber. La revisión bibliográfica se basó en siete categorías, caracterizadas según el área de estudio: actividad biológica y/o farmacológica (32 artículos), importancia del estado de conservación (29), aspectos botánicos (18), fitoquímica (9), distribución geográfica (8), forrajeo (5) y usos etnobotánicos (2). La mayoría de los trabajos abordan la actividad biológica y/o farmacológica de la especie, y su aplicación está enfocada a la acción antitumoral, tratamiento contra la enfermedad de Chagas, comportamiento antinociceptivo, acción antibacteriana, antioxidante, antiinflamatoria y antiproliferativa. Entre los compuestos aislados de C. leprosum con diferentes aplicaciones destaca el 3*β*-6*β*-16*β*-trihidroxilup-20(29)-eno, un triterpeno de lupano aislado de diferentes partes de la planta, asociado a diferentes aplicaciones medicinales y terapéuticas. La especie se destacó en trabajos asociados a la regeneración ambiental, siendo resistente a diferentes fitofisonomías y mostrando tolerancia a ambientes contaminados por metales pesados, pudiendo representar una especie importante en programas de reforestación y recuperación de ambientes degradados. Sin embargo, aún con el creciente número de estudios asociados a C. leprosum en los últimos años, la especie no cuenta con una evaluación respecto a su grado de amenaza, demostrando la necesidad de investigaciones asociadas a la especie y los posibles impactos que pueden sufrir sus representantes. ayudar en programas de conservación y desarrollo sostenible.
Palabras clave: Actividad biológica; Caatinga; Conservación; Combretaceae; Semiárido.

1. Introduction

Combretum leprosum Mart. (Combretaceae), popularly known as "mofumbo", "sipaúba" or "pente de macaco", is a plant species with a wide distribution in Bolivia, Paraguay and Brazil (Lira et al., 2002; Loiola et al., 2009). In the Brazilian

region, it occurs in the North and Northeast and part of Mato Grosso and Mato Grosso do Sul (Chaves et al., 2007). It is a native species from Brazil, widely distributed in the Caatinga of the Brazilian northeast semi-arid region (Lopes et al., 2010). *Combretum leprosum* can occur in different phytogeographic domains, such as the Amazon, Caatinga, Cerrado and Atlantic Forest (Flora do Brasil, 2022; Ribeiro et al., 2022).

It is a species capable of surviving in arid and dry climate environments with different climatic variations, losing its foliage and fruits in the dry season, presenting itself with the physiognomy of dry shrubs (Loiola et al., 2009). It has opposite leaves, petiolate with prominent veins and paniculate inflorescence of racemes, the flowers are subsessile and the fruit betuloid, elliptical, seeds accompanying the fruit, pivoting roots and cylindrical stems (Loiola et al., 2009; Ribeiro et al., 2022).

The adaptive characteristics associated with *C. leprosum* may be a result of the variety of secondary metabolites of the plant, helping in the bioregulation of important processes and maintenance in these semi-arid environments (Pietrovski et al., 2006; Agra et al., 2007; Lopes et al., 2010). The medicinal applications of the species are widely reported in the literature, using the bark, leaves and flowers as healing agents (Facundo et al., 2005; Horinouchi et al., 2013). Among the applications associated with *C. leprosum*, it stands out as a wound healing agent, soothing agent, prevention of skin rashes, hemostatic agent, treatment of flu, cough, bronchitis, sweating, diphtheria and heartburn (Facundo et al., 2005; Horinouchi et al., 2013).

The applications of the biological activity of *C. leprosum* are similar to those observed for other species of the genus *Combretum* Loefl., such as antimicrobial, antitumor and anti-inflammatory activity (Fernandes et al., 2007). Studies associated with popular use of the species demonstrate antiophidic properties, and its application against *Bothrops jararacussu* venom and hemorrhage associated with *Bothrops jararaca* venom is scientifically proven (Fernandes et al., 2007). Phytochemical studies carried out with different species of *Combretum* spp. demonstrate different classes of bioactive compounds with pharmacological importance, such as tannins, saponins, flavonoids, coumarins, glycosides, triterpenes and phenanthrene derivatives (Fyhrquist, 2007).

The phytochemical analysis of the ethanolic extract of *C. leprosum* showed the presence of monosaccharides (80%), triterpenes (10%), oligosaccharides (5%) and fatty acids (3%) (Facundo et al., 1993; Facundo et al., 2005; Evaristo et al., 2014). From the roots and leaves of the species, compounds with scientific relevance were isolated, such as arjunolic acid (2α,3β,23-trihydroxyolean-12-en-28-oic), molic acid, fatty acids, glycosylated flavonoids (3-O -meylquercetin and 3-O-α-L-rhamnopyranosylquercitrin) and the triterpene 3β-6β-16β-trihydroxylup-20(29)-ene (TTHL) (Facundo et al., 1993; Facundo et al., 2005; Evaristo et al., 2005; Evaristo et al. al., 2014). Different studies show the biological action of the triterpene 3β-6β-16β-trihydroxylup-20(29)-ene, obtained from different parts of the plant, with antimicrobial, antinociceptive, anticholinerase, anti-inflammatory and antiulcerogenic activities (Pietrovski et al., 2006; Longhi-Balbinot et al., 2009, 2012; Nunes et al., 2009; Horinouchi et al., 2013; Evaristo et al., 2014, 2017).

Given the sociocultural, economic and medicinal importance of *C. leprosum* associated with different bioactive compounds that make up the species, this article aimed to present a systematic review of production, conservation status and knowledge about the species in different fields of knowledge.

2. Methodology

A bibliographic survey was carried out in accordance with the PRISMA recommendations, where the data obtained were submitted to a flowchart divided into four stages (Galvão et al., 2015). The use of this research methodology occurred due to the greater safety, efficiency, compliance and transparency of results presented in the research results, allowing better development and clarity of reports (Galvão et al., 2015). This research fits with an applied nature and a qualitative-quantitative approach, using bibliographic sources and assistance of the meta-analysis of results (Sampiere et al., 2006). This type of study uses literature reviews and sources to demonstrate the scientific reality of the species under study, exploring documents

relevant to the research (Sampiere et al., 2006; Trindade et al., 2022).

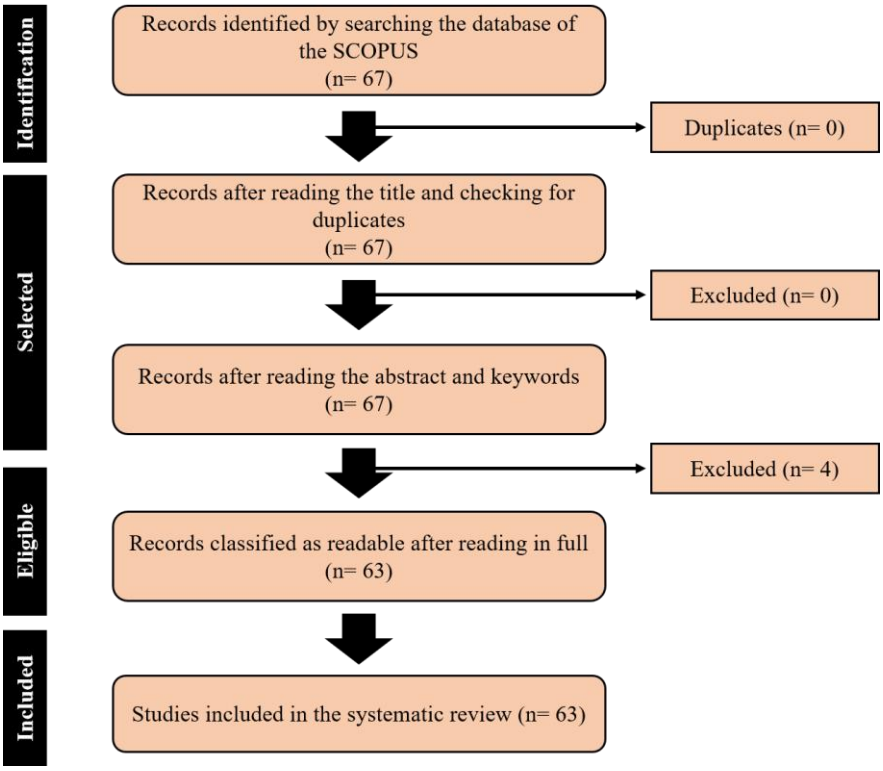
The period for searching the articles took place between the months of December 2021 and June 2022, on the *SCOPUS* platform. The choice of the platform was based on its relevance to Information Science (CI), with an extensive collection and an agreement with the CAPES Periodicals Platform, which facilitated obtaining and accessing the metadata of articles associated with the research. The description used to start the systematic review was the term "*Combretum leprosum*" with the objective of selecting permanent articles for review, as suggested by PRISMA in the information flow.

Scientific articles published between 1993 and 2022 were selected that included the scientific name of the species in the title, keywords and/or abstract of the work. The selected articles were classified according to the central theme addressed (botanical aspects, geographic distribution, biological and/or pharmacological activity, ethnobotanical uses, phytochemistry, importance of conservation status and foraging). Abstracts of events, theses, dissertations, scientific documents of technical origin, short communications and articles that did not address the central theme of the review were not included in the systematic review.

3. Results and Discussion

The initial search on the SCOPUS platform revealed 67 records, with publications between 1993 and 2022. After the initial reading of titles, abstracts and the full text, 64 articles were selected, excluding those that did not meet the established inclusion criteria (Figure 1). Among the selected records, the language used was English (57), Portuguese (13) and Spanish (1). Of these publications, 41 address only the species *C. leprosum*. The year that concentrated the largest number of publications was 2015, with seven works, followed by 2017 with six, and 2014, 2016, 2018 and 2022 with five records each.

Figure 1. Flowchart based on the PRISMA model with parameters used in the search and selection of publications.



Source: Authors.

The publications found were developed in 10 different countries, with a predominance of articles from Brazil (64),

Spain (3) and the United States (3). The literature review was based on 7 categories, characterized according to the study area: biological and/or pharmacological activity (32 articles), regeneration, conservation and management (22), phytochemistry (17), botanical aspects (03), geographic distribution (08), foraging (03) and ethnobotanical uses (02).

3.1 Biological and pharmacological activities

The bibliographic survey showed that most works address the properties and antimicrobial activities associated with compounds present in different parts of *C. leprosum*. *In vivo* and *in vitro* studies were carried out evaluating antimalarial activity, treatment against *Trypanosoma cruzi*, antioxidant, cytogenotoxic, antinociceptive activity, antibacterial, anti-inflammatory, ovicidal and larvicidal, antiproliferative, mutagenic activity, in the development of *Leishmania amazonensis*, action on snake venom, antitumor, antimicrobial effect and inhibition of planktonic growth.

Among the compounds isolated from *C. leprosum* with different applications, 3*β*-6*β*-16*β*-trihydroxylup-20(29)-ene, a lupane triterpene isolated from different parts of the plant, stands out. This compound was cited in 15 works focused on biological and/or pharmacological activity, and its application is focused on antitumor action, treatment against *T. cruzi*, antinociceptive behavior, antibacterial, antioxidant, anti-inflammatory, antiproliferative action, in the treatment of leishmaniasis and with healing potential (Table 1).

Among the studies that address the biological activity of *C. leprosum*, three show activity in the treatment against the parasite *Leishmania amazonensis*, which causes leishmaniasis (Teles et al., 2011; Barros et al., 2013; Teles et al., 2015) (Table 1). In the work by Teles et al. (2011), the action of the ethanol extract obtained from *C. leprosum* fruits was evaluated, and significant results were observed for the triterpene 3*β*-6*β*-6*β*-trihydroxylup-20(29)-ene, with inhibitory activity in the proliferation of the promastigote phase. of the parasite. A similar result was observed for the works by Barros et al. (2013) and Teles et al. (2015), who also evaluated the effect of lupane triterpene isolated from the fruits of *C. leprosum*, and it was observed that in both studies the application of this compound brought relevant results for the development of a drug with inhibitory activity and in the treatment of leishmaniasis.

The results showed that natural triterpenes isolated from *C. leprosum* have antimalarial and antiplasmodial activity, which may represent an important tool in the development of drugs associated with the treatment of malaria (Passarini et al., 2022). In addition to the antimalarial application, Araújo et al. (2021) associate the use of 3*β*, 6*β*, 16*β*-trihydroxylup-20(29)-ene in the treatment against *T. cruzi*, being observed that the compound is well absorbed in the test organism and presents low toxicity, being able to be a candidate in the developed of new options for the treatment of Chagas disease.

The triterpene 3*β*-6*β*-16*β*-trihydroxylup-20(29)-ene was studied when its antibacterial and antiproliferative action was observed, and it was observed that this compound significantly inhibited the growth of bacteria, such as *Streptococcus mutans*, *Streptococcus mitis*, *Streptococcus parasanguinis*, *Staphylococcus aureus* and *Escherichia coli*, the latter being associated with the use of the antibiotic gentamicin (Evaristo et al., 2014; Evaristo et al., 2017; Cruz et al., 2019).

In the work by Fernandes et al. (2014), the ability of *C. leprosum* extract to reduce the effects of *Bothrops jararacussu* and *Bothrops jararaca* venoms *in vivo* and *in vitro* is evaluated. Among the activities investigated in this study, phospholipase, proteolytic, collagenase, hyaluronidase, hemorrhagic, procoagulase and edematogenic action, induced in model animals (Swiss mice) stand out. The results obtained in this study show that the compounds of *C. leprosum* have important activity against the two venoms tested, which may support folk medicine that uses this plant as an alternative means for snakebite.

Table 1. Biological and pharmacological activity of *C. leprosum*.

REFERENCE	PART OF THE PLANT	ACTIVITY	TESTED SPECIES
Passarini et al. (2022)	Flowers and leaves	Antimalarial, cytotoxic and antiplasmodial activity	*Plasmodium falciparum*
Coutinho et al. (2022)	Leaves	Diabetes Mellitus Treatment	*Danio rerio*
Araújo et al. (2021)	-	Chagas disease treatment	*Trypanosoma cruzi*
Sousa et al. (2021)	Barks, stem and leaf	Antioxidant and cytogenotoxic activity	*Allium cepa*
Silva-Filho et al. (2020)	Leaves	Cytotoxicity against cancer cell lines	Against three human tumor cell lines (colon, prostate, and glioblastoma carcinoma line)
Cruz et al. (2019)	Leaves	Structural properties, bactericidal activity and modifying action of antibiotics	*Staphylococcus aureus* *Escherichia coli*
Cavalcanti, et al. (2018)	Barks	Antidiarrheal effect	Mice
Silva et al. (2018)	Leaves	Ovicidal and larvicidal activity	Goat gastrointestinal parasites
Evaristo et al. (2017)	Leaves	Antibacterial activity and antioxidant effect	*Streptococcus mutans* *Streptococcus parasanguinis*
Costa et al. (2017)	-	Protective effect in patients with Parkinson's disease	*In vivo* and *in vitro* models
Horinouchi et al. (2017)	Flowers	Anti-inflammatory and antiproliferative action	Swiss mice in acute and chronic models of induced skin inflammation
Moraes et al. (2016)	Flowers	Investigate potential neuroprotective properties	Mice
Viau et al. (2016)	Flowers	Antioxidant, cytotoxic and mutagenic activity	Yeasts of *Saccharomyces cerevisiae* and in mammalian cells (V79)
Teles et al. (2015)	Fruits	Leishmanicidal activity	*Leishmania amazonensis* in mouse macrophages
Lacouth-Silva et al. (2015)	Flowers	Cytotoxic activity	Peripheral blood mononuclear cells (PBMCs)
Alves Filho et al. (2015)	Barks	Induced relaxation	Rings of arteries of different animals
Nascimento-Filho et al. (2015)	Leaves	Healing potential	Mice
Fernandes et al. (2014)	Roots	Reduction in the effects of *Bothrops jararacussu* and *Bothrops jararaca* venom	Mice Swiss
Viau et al. (2014)	Flowers	Antitumor efficacy	Different human cell lines (breast adenocarcinoma,

			hepatoma, bladder cancer, colorectal and normal lung adenocarcinoma)
Evaristo et al. (2014)	Leaves	Antimicrobial effect and biofilm growth of gram positive and gram-negative bacteria	*Streptococcus mutans* *Streptococcus mitis*
Barros et al., (2013)	Fruits	Leishmanicidal activity	*In vitro* (mouse peritoneal macrophages) e *in vivo* (mice)
Horinouchi et al., (2013)	Flowers	Anti-inflammatory and antiproliferative action	Mice
Lopes et al., (2012)	Barks	Antinociceptive activity	Mice Swiss
Longhi-Balbinot et al., (2012)	Flowers	Nociception and vascular permeability	Mice
Teles et al., (2011)	Fruits	Leishmanicidal activity	*Leishmania amazonensis.*
Lopes et al., (2010)	Barks	Antinociceptive effect	Mice
Nunes et al., (2009)	Barks	Effect on experimental ulcers, on gastric secretion and mucus	Pyloric-linked mice
Facundo et al., (2005)	Leaves and roots	Anti-inflammatory, antinociceptive and anticholinesterastic activity	-
Lira *et al.,* (2002)	Barks	Antinociceptive activity, acute toxicity and analgesic properties	Mice

Source: Authors.

3.2 Ethnobotanical uses

The application of plants with medicinal properties by traditional communities with different ethnicities demonstrates a direct reaction between plants and human beings, having accumulated knowledge and methods acquired over time (Almeida et al., 2011; Carvalho et al., 2007; Rodrigues et al., 2007; Viu et al., 2010). This practice presents relevant efficiency due to the low cost of production and/or acquisition, especially in communities with insufficient medical care (Menezes et al., 2010; Silva et al., 2011). *Combretum leprosum* stands out in ethnobotanical studies by local communities due to its wide distribution in the northeast region, still being little studied regarding its use categories (Agra et al., 2007; Paulino et al., 2012).

In the works of Agra et al. (2007) and Paulino et al. (2012) reported the use of *C. leprosum* in two different locations, with application aimed at expectorant activity and against cough, with the bark and leaves mentioned for this purpose. Cabral et al. (2010) reported in their study that the intense and inadequate exploration of the bark of species with pharmacological activity can compromise the vascular system of the plant, which can lead to the death of the individual in extreme situations. Decoction and/or syrup were the most common forms of administration or use attributed to *C. leprosum* (Agra et al., 2007; Paulino et al., 2012).

Among the publications found that report the use of *C. leprosum* by traditional communities, only the work by Paulino et al. (2012) points to Relative Importance (RI). In this study carried out at Sítio do Gois, in Rio Grande do Norte, the RI attributed to the species was 0.43, not being very significant when compared to other species observed in the study. Bennett & Prance (2000) proposed the Relative Importance Index to determine the importance of a species according to its versatility

and use, taking into account the part of the plant used and the attributions or treatments associated with the species.

3.3 Conservation, regeneration and management

Phytosociology and floristic surveys were more predominant with regard to species conservation, with *C. leprosum* being cited in eight studies (Lacerda & Barbosa, 2020; Lima & Coelho, 2018; Pereira, et al., 2018; Sabino et al., 2016; Lima & Coelho, 2015; Umetsu et al., 2011; Silva et al., 2010; Farias & Castro, 2004). Studies that address knowledge about the floristic composition and phytosociological structure of a species or locality allow the conservation, management and recovery of natural environments (Borém & Ramos, 2001; Velazco et al., 2015).

The Importance Value Index (IVI) is associated with the ecological relevance of the species, considering the degree of occupation in the vegetation formation, density, dominance and relative frequency of the population (Queiroz et al., 2017). The IVI values of the *C. leprosum* populations studied ranged from 5.721% (Sabino et al., 2016), 24.83% (Farias & Castro, 2004), 30.26% (Lacerda & Barbosa, 2020), 31.15% (Lima & Coelho, 2018) and 41.45% (Lima & Coelho, 2015).

In the work by Primo et al. (2021) the use of litter of woody species native to the semiarid region in the replacement of nutrients to the soil is evidenced, with the presence of *C. leprosum* being observed as one of the representatives in this study. The species contributed significantly to the contribution of nutrients to the environment, and may prove to be favorable for the implementation of agroforestry systems and environmental restoration. A similar result was observed in the work by Primo et al. (2018), where litter deposition of *C. leprosum* increased phosphorus (P) and potassium (K) contents in the soil, contributing chemical attributes to the environment.

Studies associated with environmental regeneration cite *C. leprosum* as a facilitator in the establishment of species in the semiarid region (Vieira et al., 2013; Lucas et al., 2022a; Lucas et al., 2022b) and weed growth (Silva et al., 2010). In these studies, it was observed that species that grow under the canopy of *C. leprosum* present better values in water status, lower incidence of solar radiation, lower thermal stress and higher soil relative humidity (Vieira et al., 2013; Lucas et al., 2022a; Lucas et al., 2022b). These results show that the species under study contributes significantly to the process of restoration of the plant community in semi-arid environments.

It was possible to identify six studies associated with the germination and initial development of "mofumbo" seeds (Pacheco et al., 2014; Paulino et al., 2017; Leal et al., 2019; Nascimento et al., 2019; Leal et al., 2020; Guirra et al., 2021). The following parameters were analyzed: seed storage (Guirra et al., 2021), water stress and temperature variation (Leal et al., 2020), different methods of controlling microorganisms in seeds (Nascimento et al., 2019), emergence and growth of plants irrigated with saline water (Leal et al., 2019), emergence rate of seeds obtained from different individuals (Paulino et al., 2017) and evaluation of germination performance submitted to different treatments, temperature and substrate variation (Pacheco et al., 2014).

In the work by Nisgoski et al. (2018) the identification of tree species in the Caatinga from wood and charcoal was evaluated in order to assist in the control and forestry practices or illegal trade. The results obtained in this study demonstrate that the identification of *C. leprosum* can be done directly from wood and coal, and the best classification method is PCA – LDA and the analysis of complete spectra (4000-10000 cm^{-1}).

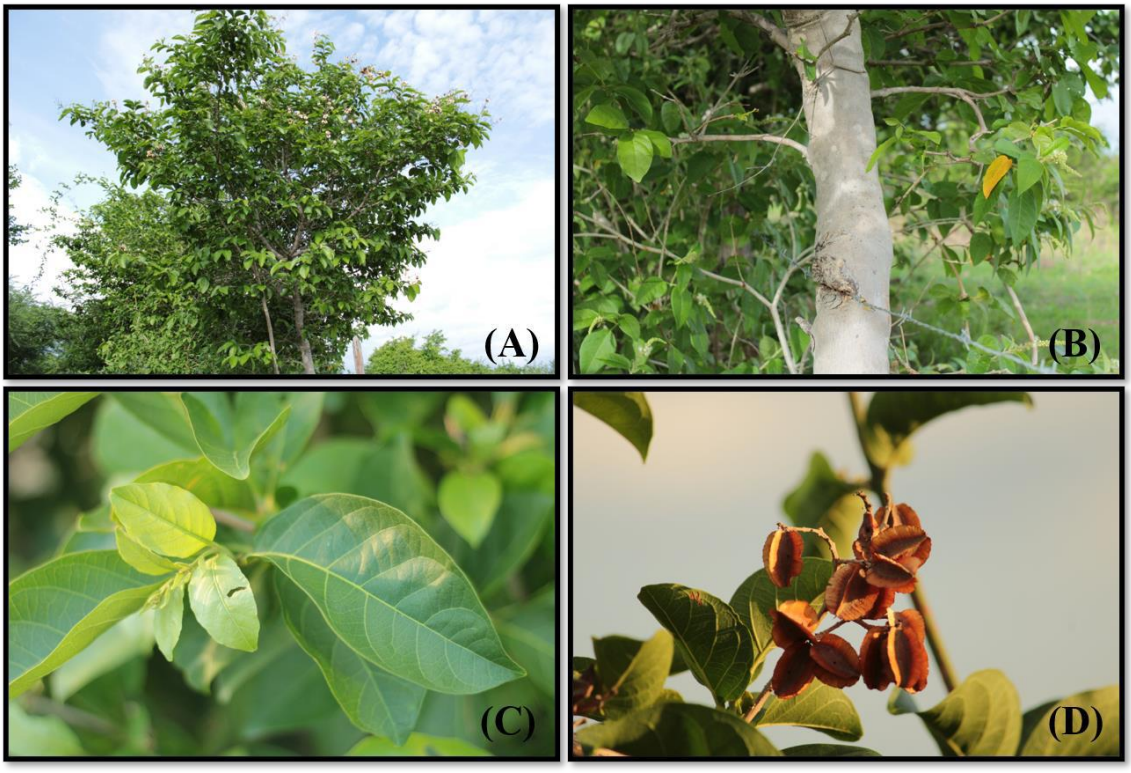
In the works by Perlatti et al. (2015a) and Perlatti et al. (2015b) the ability of plants that grow spontaneously to accumulate copper (Cu) in contaminated environments was evaluated. The *C. leprosum* species was observed in both study sites, demonstrating that the species has the ability to accumulate copper in the roots/rhizosphere, preventing the accumulation of metals in plant tissues (Perlatti et al., 2015a; Perlatti et al., 2015b). This feature is undesirable for environmental restoration sites, so that the species will not immobilize the metal, being bioavailable to the ecosystem (Perlatti et al., 2015a).

3.4 Botanical Aspects

Among the analyzed works related to botanical aspects (Ferreira, 1995; Candido et al., 2013; Pina et al., 2016), two address the leaf structure of *C. leprosum* (Candido et al., 2013; Pina et al., 2016) and a taxonomy of the genus (Ferreira, 1995). In the work by Ferreira et al. (1995), structural aspects of the species, taxonomic characters, geographic distribution, flowering and fruiting data, etiology and others are referenced. Among the morphological characters used to identify the species *C. leprosum*, are: Hypanthus superior infundibuliform or elongated-campanulate; suborbicular petals, equal to or slightly exceeding calyx lobes; scales measuring 127-252 µm in diameter, forming a group of cells in the center, delimited by white colored radial and tangential walls.

According to Ferreira et al. (1995), *C. leprosum* is arboreal or shrubby, reaching 2-8 meters in height (Figure 2A). Its stem is cylindrical with a circular outline, shiny with a grayish color (Figure 2B). Its leaves are oval with acuminate apex, of the simple and opposite type, with absent domatia and the presence of alvescent scales in both leaf phases (Figure 2C). It has yellowish flowers and elliptical or sub-elliptic fruits of the drupe type with 4 wings or wings and measuring 21.8-22 mm in length and 14-15 mm in width (Figure 2D).

Figure 2. General aspects of *C. leprosum*. A. Habit. B. Stem. C. General appearance of the sheet. D. Fruits.



Source: Almeida-Bezerra, J.W. (2022).

In the work by Candido et al. (2013), the leaf area of the species *C. leprosum* was measured using regression equations between real leaf area and linear dimensional parameters of the leaves. This type of study allows knowledge about aspects related to the propagation, development and/or growth of the species (Candido et al., 2013). In the work by Pina et al. (2016), the ability of *C. leprosum* to absorb water from dew was evaluated and to identify the anatomical structures associated with this process. In this study, the process of water absorption by trichomes was observed in the early hours of the day, allowing greater water status in the leaves and improving the conditions of the species in a semi-arid environment (Pina et al., 2016).

3.5 Geographic Distribution

C. leprosum is a neotropical species recorded in Brazil and Paraguay (Figure 3) (Ferreira, 1995). The species has a wide distribution in the Brazilian territory, occurring in the states of Paraíba (Lacerda & Barbosa, 2020; Sabino et al., 2016; Agra et al., 2007; Ferreira, 1995), Ceará (Lima & Coelho, 2018; PEREIRA et al., 2018; Lima & Coelho, 2015; Ferreira, 1995), Piauí (Farias & Castro, 2004; Ferreira, 1995), Pará, Maranhão, Rio Grande do Norte, Alagoas, Bahia, Rio de Janeiro, Mato Grosso, Mato Grosso do Sul and Goiás (Ferreira, 1995).

The species under study is present in the phytogeographic Caatinga domains (Lacerda & Barbosa, 2020; Lima & Coelho, 2018; Pereira et al., 2018; Lima & Coelho, 2015; Ferreira, 1995; Sabino et al., 2016), Campo Maior Complex (Farias & Castro, 2004), Cerrado, Seasonal Forest, Alluvial Forest and Restinga (Ferreira, 1995).

3.6 Foraging

The use of organic matter from the foliage of semiarid plants as a food resource for ruminant animals may represent a strategy to reduce the impacts associated with pasture production, in addition to contributing to food security, sustainability and greater economic viability of this market (Schader et al. al., 2015). The works of Abdalla Filho et al. (2017a), Abdalla Filho et al. (2017b) and Meier et al. (2014) addressed in their studies the use of leaves of *C. leprosum* in the feeding of Santa Inês lambs, not being observed negative results of the incorporation of this feeding in the production, health or performance of the studied animals.

Abdalla Filho et al. (2017a) observed in their study that the incorporation of "mofumbo" leaves in the diet of the animals studied reduced the production of CH_4 (methane) produced from the fermentation of carbohydrates in the intestine of these ruminants. According to Hristov et al. (2013) goats and sheep can produce an average of 10 to 16 kg of CH_4/year, contributing negatively to climate change (Hristov et al., 2013). Thus, the introduction of this species in the diet of ruminants may represent a strategy to reduce methane production by smaller animals.

In recent decades, there has been a greater concern regarding food production and sustainability, leading large producers to develop strategies that aim to improve the quality of life of animals and reduce the damage of their production to human health and the environment (Troy & Kerry, 2010; Sepúlveda et al., 2011). One of the strategies developed is the creation of ruminant animals adapted to forages of local species, in order to maximize natural fermentation and sustainable use of the ecosystem (Eisler et al., 2014; Mlambo & Mapiye, 2015).

3.7 Phytochemistry

Among the studies related to chemical compounds present in *C. leprosum*, 17 cited the presence of triterpenes, with the molecule 3*β*-6*β*-16*β*-trihydroxylup-20(29)-ene being the most reported in the studies, with 16 records (Table 2 and Figure 4). In addition to these, the presence of flavonoids, steroids, tannins, phenols and saponins was observed (Sousa et al., 2021). Arjunolic acid and molic acid (triterpenes) and 3-0-methylquercetin and quercetrin (flavonoids) were isolated from leaves and roots (Facundo et al., 1993).

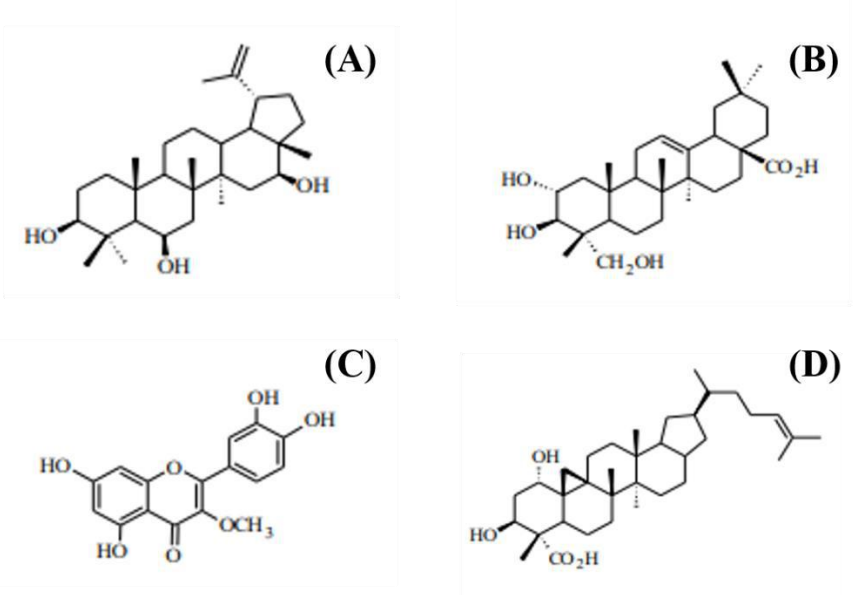
Table 2. Chemical composition of *C. leprosum*.

COMPOUND	PART OF THE PLANT	REFERENCE
3*β*-6*β*-16*β*-trihydroxylup-20(29) - ene	Leaf	Coutinho et al. (2022); Silva et al. (2020); Silva-Filho et al. (2020); Cruz et al. (2019); Evaristo et al. (2017); Nascimento-Neto *et al.* (2015); Evaristo et al. (2014); Facundo, et al. (1993)
3*β*-6*β*-16*β*-trihydroxylup-20(29) - ene	Flower	Horinouchi et al. (2017); Lacouth-Silva et al. (2015); Viau et al. (2014); Longhi-Balbinot et al. (2012); Pietrovski et al. (2006)
3*β*-6*β*-16*β*-trihydroxylup-20(29) - ene	Fruit	Teles et al. (2015); Teles et al. (2011)
3*β*-6*β*-16*β*-trihydroxylup-20(29)– ene	-	Araújo et al., (2021)
3*β*-6*β*-16*β*-trihydroxylup-20(29)– ene	Root	Facundo et al. (1993)
Arjunolic acid, mollic acid, 3-0-methylquercetin and quercentrin	Root and Leaf	Facundo et al. (1993)
Flavonoids, steroids, tannins, phenols, saponins and triterpenes	Leaf, Bark and Stem	Sousa et al. (2021)

Source: Authors.

Different parts of the plant were used in the extraction of bioactive compounds, including stem (Sousa et al., 2021), root (Facundo et al., 1993), leaf (Facundo et al., 1993; Evaristo et al., 2014; Nascimento-Neto et al., 2015; Evaristo et al., 2017; Cruz et al., 2019; Silva-Filho et al., 2020; Silva et al., 2020; Coutinho et al., 2022), flor (Pietrovski et al., 2006; Longhi-Balbinot et al., 2012; Viau et al., 2014; Lacouth-Silva et al., 2015; Horinouchi et al., 2017) and fruit (Teles et al., 2011; Teles et al., 2015).

Figure 3. Chemical representation of flavonoids and triterpenes isolated from *C. leprosum*. A - 3*β*-6*β*-16*β*-trihydroxylup-20(29)-ene; B – Arjunolic Acid; C - 3-0-methylquercetin; D – Molic Acid.



Source: Authors.

4. Final Considerations

Based on the results obtained, it is possible to perceive the increasing number of studies associated with the species *C. leprosum* in the last decade, mainly associated with the biological and pharmacological application of the triterpene 3*β*-6*β*-16*β*-trihydroxylup-20(29)–ene. These results validate the therapeutic applications of the species and encourage the increase of knowledge and, consequently, the preservation of the species, mainly in face of the anthropic pressure that the phytophysiognomies of the species have suffered.

The chemical composition of *C. leprosum* may represent an important therapeutic means in the development of drugs associated with anti-inflammatory, antioxidant, antitumor, antimicrobial and neuroprotective activity, helping to discover new biomolecules of pharmacological importance. In addition, studies on the conservation, biology and development of the species help in reforestation programs and reoccupation of degraded environments, such as the semi-arid region.

However, even with the increasing number of studies associated with *C. leprosum* in recent years, the species is classified as a "species not assessed for threat (NE)" by the National Center for the Conservation of Flora (CNCFlora). These data show the need for research associated with the degree of threat of the species and the possible impacts that its representatives may suffer, thus helping in sustainable development and conservation programs.

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