Use of essential oils extracted from the Caatinga as an alternative for the treatment of infectious diseases and inflammation

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ABSTRACT

Secondary plant metabolites, such as essential oils from the Caatinga, have diverse therapeutic properties, including antimicrobial and anti-inflammatory action. Studies highlight its effectiveness against infections, promoting alternative use in medicine. The research addressed in this work provides a comprehensive view of the therapeutic potential of essential oils extracted from medicinal plants found in the Caatinga Morphoclimatic Domain, located in Northeast Brazil. Thus, this is a systematic review of the qualitative literature, based on descriptors that follow the direction of the Health Sciences Descriptors (DeCS), used in the VHL (Virtual Health Library) search engine: "Caatinga", "Medicinal Plants", "Volatile Oils", "Anti-inflammatory", "Antibacterial", "Antiparasitic" and "Antioxidant", which were applied in the following databases: Scielo; Medline; Lilacs; PubMed and Elsevier. Several plant species and their respective essential oils were investigated, highlighting their antioxidant, antimicrobial, anti-inflammatory and antiparasitic properties. The results showed that the essential oils of Caatinga plants have a wide range of chemical

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compounds, such as terpenes, aldehydes, phenols and esters, which confer their medicinal properties. These compounds have the potential to be used as therapeutic alternatives in the treatment of various health conditions, including bacterial, parasitic and inflammatory infections. In addition, the study highlights the importance of preserving the biodiversity of the Caatinga and the traditional knowledge associated with the use of medicinal plants in the region. The integration between popular knowledge and scientific research is essential to fully explore the therapeutic potential of these plants, contributing to the promotion of public health and the development of new therapies. In addition, it is essential to ensure sustainable practices for the use and management of medicinal plants in the Caatinga, to preserve their biodiversity and the ancestral knowledge associated with their use.

Keywords: Caatinga, Medicinal Plants, Volatile Oils.

INTRODUCTION

Secondary metabolites are substances produced by plants from their primary metabolism in specific situations. Currently, much has been invested in research on the application of these substances for various purposes. Among them, it is worth mentioning studies on antioxidant, antimicrobial, anti-inflammatory, anticarcinogenic, cardioprotective action and in use outside the field of medicine (Cunha, 2016).

Volatile oils, or essential oils, are volatile compounds, a product of the secondary metabolism of plants, extracted from them through complex laboratory techniques for various uses in therapy, as they are capable of modifying the homeostasis of organisms by mechanisms that are often unknown, due to their high molecular complexity (Simões, 2017).

For Moura et al. (2019), Brazil is a country rich in plant species with therapeutic potential through the extraction of essential oils. According to the authors, the main genera of plants conducive to providing essential oils as a product of secondary metabolism are *Myrtaceae, Lauraceae, Rutaceae, Lamiaceae, Asteraceae, Apiaceae, Cupressaceae, Poaceae, Zingiberaceae and Piperaceae*, with species spread in these families.

Among the species found in Brazil, it is important to highlight that the Caatinga semi-arid morphoclimatic domain, found predominantly in the northeast region of the country, is the source of a diversity of essential oil-producing species. The volatile oils found in the Caatinga represent an important component due to their biodiversity, their application in aromatherapy, and their therapeutic purposes (Sampaio *et al.,* 2023).

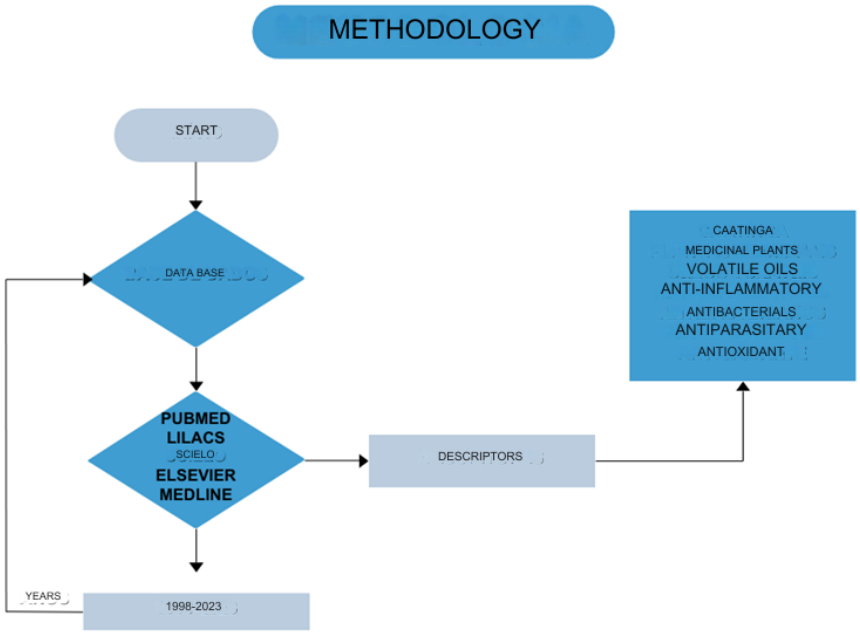
In addition to being known for their fragrance, essential oils have a medicinal function due to their antiseptic, bactericidal, fungicidal and anti-inflammatory properties. According to the National Institute of the Semi-Arid Region, in 2017, the essential oil extracted from the leaves of Jatobá (*Hymenaea courbaril*) in the city of Buíque-PE, in the northeastern region of Brazil, showed properties such as sesquiterpenes and caryophyllene oxide, substances with antimicrobial action, which proved effective as an alternative treatment for infections such as candidiasis, caused by fungi of the genus *Candida* (Gomes, 2017).

In addition, this work seeks to present a fraction of the diversity of essential oils extracted from medicinal plants present in the Caatinga biome, which play an important role as a complementary treatment of infections. It is of paramount importance that its compounds and therapeutic benefits are identified to promote alternative treatment options for the population, and it is necessary that new research be carried out and continue to look at the Caatinga in order to scientifically prove what has been rooted in popular knowledge for thousands of years, the therapeutic effectiveness of the vegetation of this biome.

LITERATURE REVIEW METHODOLOGY

For the construction of the present work, a systematic review of the qualitative literature was carried out. In which, in the search phase, the search was carried out in journal articles, books, simple abstracts, monographs, master's dissertations and theses. The present study selected some descriptors, following the guidelines of the Health Sciences Descriptors (DeCS), used in the VHL (Virtual Health Library) search engine, as shown in the figure below. With this, the following databases were selected: Scielo (Scientific Electronic Library Online); Medline (Medical Literature Analysis and Retrievel System Online); Lilacs (Latin American and Caribbean Literature on Health Sciences), PubMed (U.S. National Library of Medicine) and Elsevier. The inclusion criteria were publications between the years 1998 and 2023, in which articles in English and Portuguese were searched. In addition, articles that addressed the theme and classes of secondary metabolites describing their use were included, and those that did not fit the cited content and outside the preferred date were excluded.

Figure 1: Methodology flowchart



Source: Authorship

RESULTS AND DISCUSSION

MEDICINAL PLANTS OF THE CAATINGA MORPHOCLIMATIC DOMAIN

Brazil is a country rich not only in cultural plurality, but also in biodiversity. This is reflected thanks to the well-established characteristics of each region, bringing their richness in fauna and flora, as well as the study and search for therapeutic effectiveness of the medicinal plants of each biome (Sganzerla, 2022).

According to Dos Reis *et al.* (2023), when it comes to the Caatinga, it is important to note that it is an exclusively Brazilian biome with a semi-arid climate located in the Northeast of Brazil. This biome is characterized by high temperatures, long periods of drought and drought. For this reason, its vegetation had to develop survival mechanisms due to the low availability of water. The vegetation of the Caatinga is basically formed by xerophytic plants, shrubs and low trees that have the capacity to store a large amount of water. Despite the peculiarity of characteristics, they also have therapeutic effects when used for medicinal purposes (Emiliano; Balliano, 2019).

Popular knowledge about the therapeutic benefit of plants is rooted and passed on to the community from generation to generation, since the beginning, coming from indigenous and African culture and all the peoples that represent the matrix of Brazil. However, the region is impacted by exploratory activities of agriculture and extractivism, thus forming areas of desertification, in addition, with the advance of the pharmaceutical industry and the insertion of synthetic products, diversity and popular knowledge are threatened, requiring studies and new analyses for this knowledge and use to remain alive (Sá-filho, 2023).

Thanks to the continuity of these studies, evidence of *the* efficacy of Caatinga plants is found in the scientific literature in vitro tests. A great example is the *Amburana cearensis* (umburana-de-cheiro), used by the population in the form of teas. This plant has scientific proof of its effectiveness in the treatment of inflammations of the respiratory system such as sinusitis, bronchitis, cough and flu. It has also shown effectiveness for the treatment of rheumatism and cardiovascular problems. For this reason, a more in-depth study of other pharmaceutical forms with *Amburana cearenses* as the base active ingredient is feasible (Araújo; Amorim, 2023).

Another example to be cited is the study by Souza *et al.* (2021) which points out that *Myracrodruon urundeuva* (Aroeira) is composed of flavonoids and phenolics. Due to the presence of these compounds, the plant exhibits anti-inflammatory, antifungal, and antioxidant activities.

Essential oils extracted from Caatinga plants

According to the International Standard Organization (ISO) "Volatile oils, also called essential oils, ethereal oils or essences, are complex mixtures of volatile, lipophilic, generally odorous and liquid substances, obtained from plant raw materials" (Heinzmann; Spitzer; Simões, 2017, p. 311).

The Caatinga is a region that has many medicinal plants that produce essential oils that can be found in some parts of the plants such as: leaves; Flowers; Roots; Rhizomes; seeds and peels. These regions are responsible for characterizing the aroma of each species, with these oils performing various functions such as attracting pollinators and protecting against insects. In this way, oils also

have pharmacological effects, used for therapeutic purposes, with the main chemical compounds present: terpenes, aldehydes, phenols and esters (Fischer, 2014).

The main extraction methods for volatile oils are carried out by: water vapor drag and soxhlet apparatus. The water vapor drag method is carried out with the addition of water in the first balloon, this water needs to be heated through the heating plate. In the second flask is added the plant material that you want to remove the essential oil, the material must be crushed with a little water. When the vapor from the heated water reaches the plant material that is in balloon two, the substances present in the sample are transformed into vapor, where they are taken to the condenser. To pass from the gaseous to the liquid state, in which the liquid is collected by a beaker (Heinzmann; Spitzer; Simões, 2017).

Extraction with the soxhlet device takes place as follows: The extracting solvent is added to the flask in liquid or solid form, this flask is heated by means of a thermal blanket. With heating, a vapor is formed, which passes through the condenser, in the glass reservoir is present the plant sample, which is solubilized with the condenser. This step occurs several times, when the solvent reaches a certain limit of the condenser it comes back to repeat the entire extraction cycle (Menezes, 2016).

Thus, some examples of medicinal plants from the caatinga that are extracted from essential oils for therapeutic purposes are *Lippia sidoides*, popularly known as rosemary-pepper, *Hymenaea courbaril, a* plant known as Jatobá, from which it has in its leaves the production of essential oil and *Cymbopogon flexuosos,* called lemongrass. According to table 01, the essential oils of these plants can be found in the leaves and/or in other structures such as roots, stems and rhizomes. *Mentha piperita,* for example, has its essential oil extracted from the glandular trichomes of the plant, in which an intense amount of menthol is found (Roque, 2010).

Table 01: Main medicinal plants found in the Caatinga, producers of essential oils.

Popular name	Scientific name
Mint	*Mentha piperita*
Citronella	*Cymbopogon winterianus*
Lemongrass	*Cymbopogon flexuosos*
Eucalyptus	*Eucalyptus benthamii*
Camomile	*Chamomilla recutita*

Source: Brito, 2010.

Antibacterial activity of essential oils from the Caatinga

The medicinal flora of the caatinga presents, in many studies, antimicrobial activity, highlighting essential oils as secondary metabolites that can be applied in medicine for the treatment of microorganisms of medical interest, stating that these are a promising source for this (Dantas *et al.,* 2010). On the other hand, due to having several components in their composition, essential oils

provide a lower probability of developing bacterial resistance, since their mechanism of action is not based on just one target (Farisa, 2017).

One of the plant species in which inhibition of bacterial growth can be observed is *Croton tetradenius*, in which Silva (2019) verified the antibacterial activity of the essential oil extracted from its leaves, where the size of the halo should be greater than 10mm to consider the sample active against the strain. In this study, inhibition of the growth of *Staphylococcus aureus* and *Escherichia coli* strains was observed in front of paper discs soaked with pure essential oil in two different concentrations, both compared to the antibiotic amikacin, where the mean growth inhibition (in triplicate) was shown in Table 1.

Table 1: Diameter of the inhibition halos after analysis of the antimicrobial activity of *Croton tetradenius essential oil*.

Microorganism	**Essential oil at 10µL/ disc**	**Essential oil at 15µL/disc**	**Amicatin 30µg/disc**
Staphylococcus aureus	18mm	21mm	29mm
Escherichia coli	10mm	13mm	20mm

Adapted from Silva, 2019.

It can be observed that the essential oil of this species from the Caatinga can be promising, especially in strains of *S. aureus*. Nevertheless, it is observed that the Gram-positive strains have a greater susceptibility to the action of some of the essential oils from the caatinga. This factor is due to the action of secondary metabolites together, or isolated, such as the essential oil extracted from the bark and leaf of *Myroxylon peruiferum*, where the isoflavones 7-hydroxy-4', 6-dimethoxy-isoflavones showed both antibacterial (for Gram-positive strains), antifungal and antioxidant activities, indicating the need for a study of these in order to investigate their mechanism of action in depth (Pereira, 2018).

Not restricted only to Gram-positive bacteria, the species *Lippia gracilis* showed good results against the inhibition of the growth of strains of *Listeria monocytogenes,* as well as of the Gram-positive *Staphylococcus aureus* and *Staphylococcus epidermis*, where the diameter of the inhibition halos of the undiluted essential oil presents promising results when compared to the antibiotic chloramphenicol at 4mg/mL, as can be used to prevent the growth of Listeria monocytogenes. can be seen in Table 2 (Dantas *et al.,* 2010).

Table 2: Diameter of the largest observed inhibition halos obtained from the undiluted O.E of Lippia gracilis compared to the antibiotic chloramphenicol.

Microorganism	**Lippia gracilis *essential oil* (mm)**	**Clorafenicol 4mg/mL (mm)**
Listeria monocytogenes	34	32
Staphylococcus aureus	36	33
Staphylococcus epidermis	40	21

Fonte: Adaptado de Dantas *et al.* (2010).

In this sense, it is evident from the presentation of the studies that the essential oils of plants from the caatinga can be promising antibiotics, however more research must be done in order to find, in the flora, therapeutic options for the pathologies that afflict the population (Dantas *et al.,* 2010).

The essential oil of *Eugenia uniflora* showed antimicrobial activity against eight bacteria, in a disk diffusion test. The antibiotics used for comparison purposes were sulfadiazine and cephalothin. Its greatest antimicrobial potential was against *Listeria monocytogenes and Stapylococcus aureus*, and was not effective against gram-negative bacteria. The values of the tests are expressed in the following table (Silva, 2019).

Table 3 . Antibacterial activity of the leaf essential oil of Eugenia uniflora

Bacteria	**Inhibition zone (mm)**		
	Eugenia uniflora	**Sulfadiazine**	**Cephalotin**
Listeria monocytogenes	18 ± 3.2	30	24
Staphylococcus aureus	26 ± 7.0	36	40
Escherichia coli	10 ± 0.6	28	32
Salmonella disinteriae	N/A	30	26
Pseudomonas aeruginosa	8 ± 0.5	22	27
Salmonella enteritidis	N/A	44	28
Aeromonas hidrophila	13 ± 3.0	20	24

Source: Victoria (2012).

Antiparasitic activity of essential oils from the Caatinga

The knowledge of the native peoples of the northeast region of Brazil becomes essential for understanding the diversity of plants and their effects. A study carried out in the village of Baixa das Pedras, located in the state of Bahia, brings to light the main indications for the use of medicinal plants with antiparasitic action used daily by these peoples. In this way, plants such as aloe, mastruz, caçatinga and among other species mentioned, evidence the rich knowledge of these peoples about the medicinal properties of these plants (Santos-Lima *et al*., 2016).

Parasitosis represents one of the main causes of death worldwide and a worrying health problem, covering about two to three million deaths per year. These pathologies are associated with social, environmental, cultural and economic factors, with most of those affected living in areas that still lack adequate infrastructure and are routinely exposed to contaminated food and infected soils (Wiebbelling, 2015).

Rosa *et al.,* (2003) conducted a study of the anti-Leishmania *amazonensis* activity of the essential oil of *Croton cajucara leaves*, and noted that the plant acted in the reduction of the association between parasites and macrophages. In this study, it was identified that linalool, a substance present in the essential oil, could be responsible for the effects described in addition to inhibiting macrophages. Under this bias, the selectivity of this oil has been proven and new studies cite the oil as a promising source for the treatment of leishmaniasis.

In addition, the essential oils of *Copaifera reticulata* and *Lippia sidoides were also tested* against the promastigote forms of *Leishmania*, the results showed that the aforementioned oils were effective compared to the positive control pentamidine (Rondon *et al.,* 2012). Furthermore, Zheljazkov *et al.,* (2008) also showed that minority constituents such as δ-cadinene, found in basil essential oil, had inhibitory effects against *Leishmania donovani*.

In a study carried out by researchers from the Institute of Physics of São Carlos (IFSC) of USP, the activity of Citronellol, a chemical compound present in essential oils of several species, including the essential oil of *Lippia Citriodora,* which showed an important antiparasitic action against *Schistosoma mansoni, was described.* etiological agent of schistosomiasis. In this research, it was found that the terpene Citronellol is capable of damaging the external body structure of the parasite, causing difficulty in its survival (Mafud *et al.*, 2016).

Antioxidant activity of essential oils from the Caatinga

It is highlighted how the *Libidibia ferrea* plant has several groups, such as terpenes, phenolic compounds and flavonoids, which justify its popular use as anti-inflammatories, in addition to its use as hypoglycemic agents, corroborated by its enzymatic activity that helps control glucose levels. (Jacob *et al.,* 2022)

Urera *bacífera* has in its composition the presence of flavonoids, in addition to antioxidant and anti-inflammatory and even gastroprotective activity, in view of its action of reducing pepsin and modulating the action of interleukins 10, 6 and 4 (Benvenutti *et al.,* 2020). While *Hymenaea cangeceira*, popularly known as jatobá has anti-inflammatory, antioxidant and analgesic properties in the ethanolic and organic extracts of its essential oil, its anti-inflammatory capacity has been compared to other analgesics in mouse models, in addition, it also has antimicrobial activity against the formation of colony films of Gram positive and negative bacteria. (Veras *et al.,* 2020)

According to studies carried out with mice, the essential oils of Alibertia *edulis* have an enzymatic potential to protect against hyperglycemia and dyslipidemia, even in animals exposed to diets that put them at risk with hypercaloric, influencing catabolism without signs of toxicity (Aquino *et al.,* 2020).

Amburana cearensis, which is popularly used in urinary and respiratory tract infections, also has its antioxidant property discussed, highlighting how in vivo models its extract protects cells of the nervous system against inflammation. (Pereira *et al.,* 2017).

Syzygium jambos has in its phytochemical activity a large amount of flavonoids, associated with antioxidant activity, in addition to the *in vivo studies* discuss the influences of the aqueous extract of this plant on the action of catalytic enzymes such as peroxidase and glutathione, in addition

to the potential to modulate the action of nitrous oxide, and protection against oxidative stress in neuronal cells. (Bonfanti *et al.,* 2013).

In a study where more than 30 plants were analyzed with possible antioxidant activities and belonging to the Caatinga Morphoclimatic Domain, the following were highlighted: *Passiflora cincinatta, Callisia repens, Byrsonima gardneriana, Serjania glabrata, Diospyros gaultheriifolia, Cordia globosaand, Myrsine coriacea.* None of these plants has antioxidant activity comparable to a drug, however, in addition to having low toxicity, they can be very important sources of substances that protect against oxidative stress (David *et al.,* 2007).

In one of the studies developed with ethanolic extract of *Achyrocline satureioides,* a high amount of flavonoids was found, more than 80%, however, in vivo, this extract showed toxicity, encouraging the peroxidation of lipid membranes very easily (Polydoro *et al.,* 2005).

The aqueous extract of the stem of *Ziziphus joazeiro* has medium potential activity against plaque-forming bacteria and caries, in addition to presenting low toxicity (Alviano *et al.,* 2008). In addition, the aqueous and methanolic extract of *Achyrocline satureioides*, popularly known as marcela, had its oxidation modulating activity proven (Desmachelier *et al.,* 1998).

Anti-inflammatory activity of essential oils from the Caatinga

Essential oils obtained from plants of the genus *Croton* (*Euphorbiaceae*) have a pleasant aroma and represent sources of biologically active molecules, which give rise to chemically distinct compounds of great scientific relevance and widely used in popular therapy. The objective of this study was to investigate the anti-inflammatory effect of OECz and anethole in mouse models of paw edema in mice, both in carrageenan-induced non-immune animals and in ovalbumin-induced sensitized animals. Both showed anti-edematogenic activity, inhibiting kinins and nitric oxide in acute inflammations. (Bridges *et al.,* 2009).

Eugenia gracilima, an important plant in the Caatinga with anti-inflammatory properties, is widely used by the population, despite the scarcity of reports in the literature about its medicinal potential. Thus, the essential oil was obtained by hydrodistillation of the leaves, identified for its chemical composition and evaluated for acute toxicity and anti-inflammatory activity. In the paw edema test, tested concentrations of OEEg inhibited inflammation by up to 98.20%, indicating safety and efficacy in reducing inflammation. (Guedes, 2021).

The Caatinga biome also has plants of the genus *Lippia* (Verbenaceae), traditionally used in the treatment of disorders related to the respiratory system and gastrointestinal problems. Such plants have been studied as essential oils in the treatment of edema, acting as an anti-inflammatory (Lima, 2018).

Eugenia brejoensis is a species used in traditional medicine for the treatment of inflammatory diseases, pain in general and fever. Although essential oils have interesting biological activities, their pharmaceutical use is limited due to their physicochemical properties. Oral administration of the oil and the inclusion complex showed no acute toxicity or genotoxicity. The results obtained validate its relevant use in formulations developed for application in new pharmaceutical presentations (Silva, 2022).

Myracrodruon urundeuva Allemão (Aroeira-do-Sertão), belonging to the *Anacardiaceae* family, is widely used in folk medicine in the Brazilian Northeast due to its anti-inflammatory, healing and anti-ulcer properties. The study investigated replacing the bark of the adult tree with developing shoots to conserve the species and provide raw material. The extracts of the sprouts were chemically characterized and evaluated for their gastroprotective and anti-inflammatory activities, similar to those of the inner bark, indicating viability for sustainable pharmaceutical use (Galvão *et al.,* 2018)

Plectranthus species, mainly *Plectranthus barbatus* (Boldo), due to their analgesic and anti-inflammatory potentials. The results show that extracts from various species possess significant anti-inflammatory activity, demonstrated by the inhibition of pro-inflammatory mediators and inflammatory enzymes. These results highlight the potential of *Plectranthus species* as sources of bioactive compounds with therapeutic applications (Barbosa *et al.,* 2023).

Hymenaea martiana, known as "Jatobá" in northeastern Brazil, is used in folk medicine to treat pain and inflammation. In order to prove its applicability, tests were carried out on mice to evaluate its antinociceptive and anti-inflammatory activity. The results obtained in the tests proved the efficacy of *Hymenaea martiana* in reducing the migratory activity of the inflammatory process. Highlighting the importance of studies focused on the powers of the Caatinga, as another source of therapeutic resources (Pacheco *et al.,* 2022).

CONCLUSION

In view of the above, it is evident that the caatinga is a biome rich in biodiversity, in addition to several species of medicinal plants can be found in its flora. The secondary metabolites present in these plants are the target of constant research to understand the pharmacological mechanisms they present.

One of the ways in which the caatinga plants are used medicinally is through essential oils, which demonstrate antimicrobial, antioxidant and anti-inflammatory activities, serving as an incentive for new study targets with this metabolite.

Therefore, it is essential to deepen interdisciplinary studies in order to fully explore the therapeutic potential of medicinal plants from the Caatinga, through the integration of traditional

knowledge with contemporary scientific approaches. This approach not only allows the appreciation and preservation of the unique biodiversity of this biome, but can also result in significant contributions to the promotion of public health, expansion of the therapeutic network and the progress of scientific knowledge, for the benefit of society as a whole.

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