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Survey of Species Cultivated in Brazil and their Biological Applications: A Review

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Medicinal plants are the basis for the development of numerous drugs, ensuring their effectiveness through pharmaceutical properties, from antimicrobial action to the treatment of infectious diseases. Thus, the present study aimed to carry out a survey of the species cultivated in the municipal garden of Sobral - CE, Brazil, in order to verify in the literature, the medicinal potential and their biological properties. For this, the survey was carried out between January and February 2022, while the bibliographic review followed through the PubMed, SciElo and LILACS platforms. The survey identified 70 species, divided into gardening, fruit, medicinal, native and arboreal groups. Of these, about 90.9% had some therapeutic properties, whether antimicrobial, antiparasitic, antioxidant, anti-inflammatory or antinociceptive. Some of these even exhibited all these properties, as is the case of *Moringa oleifera*, becoming a model for studies. Thus, the raised

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species have potential for the development of new therapeutic alternatives, whether in the development of a new drug from extracts and essential oils, or even through the enhancement of existing drugs.

Keywords: Antimicrobial action; antioxidant action; anti-inflammatory action; medicinal plants.

1. INTRODUCTION

The biodiversity of plants present in northeastern Brazil represents a large portion nationwide, being used as ornamental, fruitful or even as herbal medicine for the treatment of a multitude of diseases [1]. These species combined with ethnic and cultural diversity resulted in a rich traditional medicine, becoming the basis for the development of knowledge and innovative scientific technologies capable of transforming the pharmaceutical market [2].

In recent years, there has been an increase in the use of medicinal plants in the public health system as a complement to some treatments [3]. According to the World Health Organization (WHO), the use of this Traditional and Complementary Medicine is defined as a set of practices, products and knowledge grouped together and not belonging to conventional medicine [3]. In this line, the WHO is implementing the strategy of traditional medicine from 2014 to 2023, having as guidelines the quality and safety of herbal medicines, methodologies for the clinical study of traditional medicine and definition of terminology and classification of species and possible treatments [4].

Numerous studies point to the action of these plant species, from antimicrobial, antiviral, antiparasitic potential, to analgesic, anti-inflammatory action and in the treatment of minor diseases [5]. This activity is related to the active principles that are responsible for provoking responses in the body that consumes it [5]. Such principles are substances synthesized from light energy and nutrients that the plant can extract from the soil [6]. According to the chemical structure, these substances can be organic acids, alkaloids, anthraquinones, phenolic compounds, coumarins, steroids, flavonoids, cardioactive or cardiotonic glycosides, heterosides, mucilages, essential oils, among others [6].

Within this perspective, Gardens of Medicinal Plants represent great importance, contributing significantly to the preservation of species, and consequently, knowledge and tradition in the use of these plants [7]. Located 242 kilometers from the capital Fortaleza - CE, Brazil, the garden in the Municipality of Sobral – CE, Brazil, produces about 100,000 species per year, meeting the demands for planting in public areas, as well as making the population available for their own planting.

Thus, the study aimed to carry out a survey of the species cultivated in the municipal garden of Sobral - CE, Brazil, in order to verify in the literature their medicinal potential and their antimicrobial properties. Therefore, the study seeks to characterize these plants in order to scientifically base their use for therapeutic purposes, as well as being the basis for applied studies.

2. MATERIALS AND METHODS

The survey of species was carried out between the months of January and February 2022 in the Horto of the Municipality of Sobral - CE, Brazil, in which it was verified which species were most requested, both for afforestation in the city and for local residents. With the objective of describing the possible potential of these plants, a study of the current literature was carried out, pointing out antimicrobial, antiparasitic, antioxidant, anti-inflammatory and antinociceptive action. The literature review was performed using PubMed, SciElo and LILACS platforms.

3. DEVELOPMENT

The survey resulted in 70 species organized into groups, such as those for gardening, fruit, medicinal, native and afforestation plants (Table 1).

It is possible to notice that 38.57% of the plants present in the municipal garden of Sobral-CE, Brazil, are part of the plants used for gardening, 14.28% are medicinal plants, 35.71% are native plants of Brazil, and that 11.43% are used for afforestation.

Table 1. Species cultivated in the municipal garden of Sobral – CE, Brazil

Gardening	
Popular name	**Scientific name**
money	*Callisia repens*
Me and you	*Euphorbia milii*
Horse face	*Philodendron Panduriforme*
garden flamboyant	*Delonix regia*
palm tree hawaii	*Veitchia merrillii*
gold drop	*Duranta erecta*
white grass	*Chloris polydactyla*
Zabumba	*Brugmansia suaveolens*
purple vine	*Allamanda blanchetti*
Spear of Saint George	*Brugmansia suaveolens*
Croton (painted)	*
croton (petra)	*Codiaeum variegatum*
pitaya	*
Roxinha	*
Cambric	*
Juicy	*
mini seal	*
Eleven o'clock	*Portulaca grandiflora*
crawl	*
white jasmine	*
Mango	*Mangifera indica*
cashew	*Spondias mombin*
Acerola	*Malpighia emarginata*
Cherry	*Prunus subg. Cerasus*
cashew tree	*Anacardium occidentale*
earl	*
Guava	*Psidium guajava*
Medicinal	
anador	*Justicia pectoralis*
Artemisia	*Artemisia vulgaris*
mauve	*Plectranthus amboinicus*
Mint	*Mentha piperita*
Saffron	*Curcuma longa*
Meracillin	*Alternanthera brasiliana*
Courama (Malva coruda)	*Bryophyllum pinnatum*
bilberry	*Plectranthus ornatos*
lemon balm	*Melissa officinalis*
Holy grass	*Cymbopogon citratus*
Native	
inga	*Inga edulis*
white stick	*Picconia azorica*
white ipe	*Tabebuia roseo-alba*
yellow ipe	*Handroanthus albus*
pink ipe	*Handroanthus heptaphyllus*
fake white dick	*Auxemma oncocalyx*
Mungulu	*Erythrina verna*
imburana	*Commiphora leptophloeos*
Pereiro	*Aspidosperma pyrifolium*
cow foot	*Aspidosperma pyrifolium*
Ipe perobinha	*
Purple IPE	*Handroanthus impetiginosus*
Timbaúba	*Enterolobium contortisiliquum*
eighth	*Licania tomentosa*

Gardening	
Popular name	**Scientific name**
Pajeú	*Triplaris gardneriana*
Munguba	*Pachira aquatica*
Jucá	*Libidibia ferrea*
Marizeira	*Calliandra spinosa*
big belly	*Ceiba glaziovii*
trapia	*Crataeva tapia L.*
ipê do cerrado	*Tabebuia ochracea*
Craibeira	*Tabebuia aurea*
You knew	*Mimosa caesalpiniifolia*
Canafístula	*Peltophorum dubium*
Coité	*Crescentia cujete*
AFFORESTATION	
Acacia	*Acacia spp.*
moringa	*Moringa oleifera*
Jatoba	*Hymenaea courbaril*
mango jasmine	*Plumeria rubra*
Cola	*
gliricidia	*Gliricidia sepium*
flamboyant	*Delonix regia*
Baobab	*Adansonia digitata*

**No scientific identification*

3.1 Antimicrobial Activity

It is known that some plants, mainly extracts and essential oils, exhibit antimicrobial action against a variety of pathogens, effectively contributing to the development of new drugs [8]. Among the plants raised in the study, *Euphorbia milii*, *Allamanda blanchetti* and *Codiaeum variegatum* from the gardening group, have antimicrobial activity [8]. The first, *E. milii*, also popularly known as the "eu e tu" plant, has antimicrobial potential against *Klebsiella pneumonia* and *Staphylococcus epidermidis*, mainly related to the presence of cardiac glycosides, steroids/phytosterols, anthocyanins, proteins, terpenoids, flavonoids and tannins in its extract [8]. The extract of the species *A. blanchetti* presents action against the bacteria *Bacillus subtilis*, *Staphylococcus aureus*, *Sarcina lutea*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Salmonella paratyphi*, *Shigella dysenteriae*, *Vibrio parahaemolyticus* and the fungi *Saccharomyces cerevisiae* and *Aspergillus niger* [9]. Finally, the species *C. variegatum* demonstrates to have antibacterial action against bacteria *Escherichia coli*, *P. aeruginosa*, *Bacillus subtilis* and *S. aureus*, antifungal action against *Alternaria alternata* and *Fusarium oxysporum*, as well as, antiviral action against influenza A viruses [10-11].

In the group of fruit plants, *Mangifera indica* is of great importance, exhibiting antimicrobial action against *E. coli*, *S. aureus*, *Candida albicans* and *Mycobacterium smegmatis*, in addition to action against oral microorganisms [12-13]. In addition to this, the extract of the species *Spondias mombin*, routinely used against gastrointestinal infections, demonstrates action against Gram-negative bacteria, and synergistic effect with some antibiotics (gentamicin and imipenem against *S. aureus* and *E. coli* and norfloxacin against *P. aeruginosa*) [14]. Another study showed the antiviral action of the extract of this species against the Herpes Simplex virus type-1, related to the interaction of the geraniin molecule with the gB viral surface glycoprotein, which is responsible for adsorption [15]. As for the fruit species *Malpighia emarginata*, studies have shown the antifungal action of its saline extract against some species of the genus *Candida*, also demonstrating its ability to interfere with the formation of the biofilm of these fungi [16].

Along the same lines, studies have shown that fractions of the species *Prunus subg*. Cerasus also has antimicrobial action, inhibiting the growth in the planktonic form and biofilm of *Candida albicans*, *Streptococcus mutans* and *Fusobacterium nucleatum*, also functioning as an epithelial barrier preventing infection by these pathogens [17]. With regard to the species *Anacardium occidentale*, studies demonstrate the action of extracts and fractions of its leaves against *Listeria monocytogenes* [18], *S. aureus*, *B. subtilis*, *Salmonella enterica*, *Shigella*, *E. coli*

[19], *P. aeruginosa*, *Proteus mirabilis, K. pneumoniae*, *C. albicans* [20] and stem bark extract against *Streptococcus mitis*, *S. mutans*, *S. sanguis* and *S. sobrinus* [21], among others. Finally, among the fruit species raised in the current study, the extract of *Psidium guajava* also demonstrates great antimicrobial potential against oral bacteria, mainly related to the presence of the compounds β-selinene, α-humulene and β-caryophyllene [22-23], in addition to this action, the essential oil of this species also demonstrated activity against *Curvularia lunata* and *Fusarium chlamydosporum* [24].

Among the medicinal plants surveyed, the oily fraction of *Artemisia vulgaris* demonstrates great antimicrobial action against the fungus *C. albicans* and *A. niger*, in addition to the bacteria *E. coli*, *Salmonella enteritidis, P. aeruginosa*, *K. pneumoniae*, *S. aureus* and *S. mutans*, probably associated with the presence of essential oils, 1,8-cineol, α-thujone and camphene [25-26]. In addition, *Plectranthus amboinicus* exhibits antimicrobial action against planktonic cells and biofilm of *S. aureus* resistant to vancomycin and oxacillin, in addition to *E. coli* and *Salmonella typhimurium*, this activity is related to the compound cracavol [27]. It also exhibits antifungal activity against *A. flavus*, *A. niger*, *A. ochraceus*, *A. oryzae*, *C. versatilis*, *Fusarium* sp., *Penicillium* sp., *S. cerevisiae*, *C. albicans*, *C. tropicalis*, *C. krusei* and *C. stellatoidea* [28]. Another species that has antimicrobial activity is *Mentha piperita*, with essential oil demonstrating action against *Klebisiella* spp., *S. aureus*, *S. epidermides*, *E. coli*, *S. enteritides*, *Micrococcus flavus*, among others [29], in addition to the fungal strains *Fusarium moniliforme*, *A. niger*, *A. fumigatus* and *C. albicans* [30].

In addition, the extract of the species *Curcuma longa* has been shown to be effective against bacteria that cause periodontitis, in addition to inhibiting the planktonic form and biofilm of *S. aureus* and *P. aeruginosa* [31-32]. Antifungal action was also evidenced against *Trichophyton mentagrophytes*, *T. rubrum*, *Epidermophyton floccosum* and *Microsporum gypseum* [33]. With regard to the *Alternanthera brasiliana* species, studies point to its effectiveness when used in combination with the antibiotic gentamicin, exhibiting a synergistic effect against *S. aureus*, *E. coli* and *P. aeruginosa*, related to the compound luteolin, the majority in its extract [34]. As for the species *Bryophyllum pinnatum*, studies indicate that its extract demonstrates effectiveness in inhibiting the bacterium *Helicobacter pylori* in an in vivo model, with a significant reduction of this in the gastric mucosa [35]. In this line, the dichloromethane extract and the essential oil of the *Plectranthus ornatos* species also demonstrate antibacterial action against Gram-positive bacteria in their planktonic form, as well as in biofilm [36]. In addition, the *Melissa officinalis* species demonstrates activity against Gram-positive and Gram-negative bacteria, as well as the fungi *C. albicans* and *S. cerevisiae* [37]. Finally, the essential oil of the *Cymbopogon citratus* species demonstrates antibacterial action against Gram-positive and Gram-negative bacteria related to the synergism of its compounds [38].

In the native group, Inga edulis stands out for its antifungal action against species of the genus *Candida* [39]. In addition, *Auxemma oncocalyx* demonstrates action against *S. aureus*, both in its planktonic form and in biofilm, related to the benzoquinone molecule [40]. Another species with this action is *Commiphora leptophloeos*, exhibiting antimicrobial potential against methicillin-resistant *S. aureus*, *Mycobacterium smegmatis*, *M. tuberculosis*, in addition to antifungal action against *Candida* species in planktonic and biofilm forms [41-42].

In addition, *Handroanthus impetiginosus* also exhibits antibacterial action against *S. aureus*, *Listeria monocytogenes* and *Streptococcus agalactiae*, this action is associated with coumarins, tannins, flavonoids and steroids present in the ethanolic extract of flowers of this species [43]. *Licania tomentosa* also demonstrates antimicrobial action against *S. aureus*, *Bacillus cereus*, *E. coli* and *K. pneumoniae* strains, related to the synergism present in the extract [44]. With regard to the *Triplaris gardneriana* species, studies have shown quercetin as one of the main compounds, with antimicrobial action against Gram-positive and Gram-negative bacteria [45]. Also, *Libidibia ferrea* demonstrates action against the planktonic form and biofilm of *S. mutans*, exhibiting anticariogenic action [46]. *Mimosa caesalpiniifolia* also has antimicrobial action, mainly against *S. aureus* and *C. albicans* with a mechanism aimed at inhibiting the efflux pump [47]. In addition to these*, Peltophorum dubium* demonstrates antifungal action against *A. flavus*, with a mechanism aimed at the disruption of hyphae [48]. Finally, *Crescentia cujete* has antibacterial action against *S. aureus*, *E. coli* and

Vibrio harveyi with a mechanism aimed at disturbing the microbial membrane [49-50].

In addition, species destined for afforestation were also surveyed, in this sense the ethanol, chloroform and ethyl acetate extreacts of *Moringa oleifera* leaves stand out with action against Gram-positive and Gram-negative bacteria, in addition to antifungal activity against *A. flavus*, *A. niger*, *Trichoderma* sp and *Candida* spp. [51].

3.2 Antiparasitic Activity

The antiparasitic activity has also been very evident among botanical species [52]. The current research identified the species *Euphorbia milii*, *Veitchia merrillii* and *Codiaeum variegatum* with this potential within the gardening group [52]. Studies have shown that the hydroalcoholic extract of the species *Euphorbia milii* has ovicidal action against *Ancylostoma* spp., with significantly low toxicity against *Artemia salina* [52]. In this line, the ethanol extract of the species *Veitchia merrillii* is capable of inducing surface changes in adult worms of *Ascaridia galli* [53]. While in vitro studies show the antiamoebic action of the species *Codiaeum variegatum* [10].

Among the species of the fruit group, *Mangifera indica* also has antiparasitic action, preventing the development of *Haemonchus contortus* larvae [54]. In addition, the extract of the species *Spondias mombin* has demonstrated antiparasitic action against *Haemonchus placei* related to the compound Phaeophorbide-a, however, it does not present cytotoxicity for cell lines H460, Caco-2, MC3T3-E1 [55]. In this line, some constituents of the *Anacardium occidentale* species have demonstrated effective action against *Trypanosoma cruzi*, mainly cardol, acting as a sirtuin inhibitor, these are involved in the deacetylation of lysine residues of proteins acting as regulators of DNA repair, in the morphology of the parasite and other crucial aspects for its survival [56]. In addition, a study carried out by Alvarenga et al. (2016) demonstrated the action of the compound 2-methylcardol diene from *A. occidentale* against adult worms of Schistosoma mansoni, causing damage to the interstitial tissue and mitochondria [57]. Also, among fruit species, *Psidium guajava* demonstrates great antiparasitic action against *Leishmania infantum* related to two main compounds, jacumaric acid and corosolic acid [58]. Furthermore, in a study carried out by Silva et al (2019), the antiparasitic action of this species was demonstrated from the pro-oxidative activity, caused by the increase in total proteins, intracellular H2O2 and lipid peroxidation products, in addition to the increase in the level of enzymes glutathione S-transferase and superoxide dismutase [59].

In the group of medicinal plants raised in the current study, *Artemisia vulgaris* shows action against *Plasmodium yoelii* and *P. berghei* and *Trichinella spiralis* [60-61]. The species *Curcuma longa* also demonstrates an antiparasitic effect, with nanoformulations based on curcumin, with effect against *S. mansoni* demonstrating damage at the molecular level [62]. In addition to these, the *Bryophyllum pinnatum* extract demonstrates action against *Plasmodium falciparum*, one of the species that causes malaria in humans [63]. For the *Melissa officinalis* species, studies point to the action of the essential oil against *Leishmania amazonenses*, mainly associated with its neral and citral compounds [64]. In this line, the species *Cymbopogon citratus*, studies point to its effectiveness against *P. chabaudi* and *P. berghei*, as well as, anthelmintic action against *Haemonchus contortus* [65-66].

With regard to the group of native plants, *Aspidosperma pyrifolium* stands out, demonstrating great in vitro potential of its extract and fractions against *P. berghei*, without showing cytotoxicity [67]. Furthermore, fractions of the leaves of *Tabebuia aurea* showed antileishmania action related to the compounds oleanolic acid and ursolic acid [68].

Among the species intended for afforestation, *Moringa oleifera* has a high antiparasitic action, studies indicate that the hydroalcoholic extract of its leaves is capable of reducing the egg count of *Trichuris* ssp. and *Ostertagia* sp., also contributing as a food additive for some animals [69]. In addition, the ethanolic extract of the leaves of *Gliricidia sepium* demonstrates high activity against *H. contortus*, exhibiting approximately 91.2% inhibition [70].

3.3 Antioxidant Activity

The antioxidant action of these plants has also been discussed [71]. In the gardening group, the species *Callisia repens*, *Euphorbia milii*, *Delonix regia*, *Duranta erecta* and *Allamanda blanchetti* stand out. In this line, the species *Callisia repens* has as main components total flavonoids, total anthocyanins and sugars, having its high antioxidant action related to the synergism of these molecules, with elimination of DPPH·, and scavenging of free radical ·OH, in addition to a low content of heavy metals [71]. The *Euphorbia mili* species also has an antioxidant action, especially when chloroform fractions are used, demonstrating a great elimination of DPPH radicals [8]. The *Delonix regia* chloroform fractions also has as antioxidant action, especially when are used, demonstrating a great elimination of DPPH radicals [8]. The *Delonix regia* species, on the other hand, demonstrates potent antioxidant action related to three flavonoids: rutin, isoquercitrin and myricetin, still presenting low toxicity to healthy cells [72]. Leaf and fruit extracts of *Duranta erecta*, has an antioxidant action mainly associated with several photochemical compounds including flavonoids [73-74-75]. Finally, *Allamanda blanchetti*, demonstrates the high elimination of free radicals of DPPH, with soluble fraction of carbon tetrachloride [9].

In the second group, fruit trees, *Mangifera indica* is highlighted, with studies demonstrating its antioxidant potential [76]. Study carried out by Banerjee et al. (2020. Also, in another study, the antioxidant potential phenolic compounds obtained from the skin of the fruit of this species was demonstrated using the for TPC, DPPH and ORAC methods [77]. The *Spondias mombin* species also demonstrates antioxidant action related to the compounds found in its seeds, namely dodecanoic acid, tetradecanoic acid, n-hexadecanoic acid, capsaicin and dihydrocapsaicin phenolamides [78]. As for the *Malpighia emarginata* species, its antioxidant capacity is supported by the phenolic compounds, ascorbic acid and malic acid [79-80]. In addition, a study carried out by Barros and Melo (2019) verified that the extract of *Malpighia emarginata* is capable of increasing the scavenging of free radicals (38.59%) promoting a greater reduction of ferric ions [81]. With regard to the species *Prunus subg*. Cerasus, Garcia et al. (2015) demonstrated the obtaining of peptides with antioxidant potential with the use of three enzymes (Alcalase, Thermolysin and Flavourzyme) from its seeds, evaluating the ability to scavenge radicals and reduce lipid peroxidation [82]. The results showed that those peptides obtained with Flavourzyme were the ones with the lowest antioxidant action compared to the other two groups [82]. Another plant from the fruit group is *Anacardium occidentale*, whose leaf extract exhibits antioxidant action in the treatment of RAW 264.7 macrophage cells, with a significant reduction in oxidative damage, in addition to reversing the oxidative damage of cells induced by LPS [83]. In addition to these, leaf and fruit extracts of the *Psidium guajava* species show great antioxidant action using the DPPH, CUPRAC and FRAP methods related to the content of phenolic compounds, more precisely: Quercetin, quercetin-3-O-α-D-arabinopyranoside, quercetin- 3-O-α-D-ribopyranoside, quercetin-3-O-β-D-galactopyranoside, quercetin-3-O-α-D-glucopyranoside, and quercetin-3-O-α-D-xylpiranoside [85-86].

For the group of medicinal plants, *Artemisia vulgaris* has proven antioxidant action by different methods: DPPH, lipid peroxidation, protein glycation, xanthine oxidases, ABTS, hydroxyl superoxide, nitric oxide, ferric reducing power activity and inhibition of lipid peroxidation by assays of reactive species of thiobarbituric acid, with the capacity to increase the level of ascorbic acid and glutathione [87]. This action is related to flavonoid compounds, flavonols, phenolic acids [87]. In this sense, *Plectranthus amboinicus* also demonstrates oxidizing action, significantly inhibiting the formation of free radicals and DPPH hydroxyl radicals, with action related to carvocrol and thymol [88]. Another species with this action is *Mentha piperita*, with essential oil showing DPPH radical scavenging [89]. The *Curcuma longa* species also has antioxidant effects, studies indicate that its extract reduces the levels of malondialdehyde and nitric oxide, increasing the levels of thiol, superoxide dismutase and catalase under conditions of oxidative stress [90]. With regard to the species *Alternanthera brasiliana*, a study carried out by Marchete et al. (2021) demonstrated its antioxidant action *in vitro* and in *vivo in* a murine model, stimulating angiogenesis and tissue healing [91]. Studies indicate that the extract of *Bryophyllum pinnatum* has a great antioxidant effect, mainly associated with the synergism of the compounds luteolin-7-glucoside, carlinoside and quercetin [92]. The *Melissa officinalisa* species, on the other hand, presents high antioxidant activity, through its chemical compounds, including high amounts of flavonoids, rosmarinic acid, gallic acid and phenolic content [93]. Finally, the *Cymbopogon citratus* species exhibits antioxidant action in kidney lineage cells, increasing cell viability and proliferation and decreasing oxidative stress caused by rotenone [94].

Another group raised was that of native plants, in which Inga edulis has a high antioxidant action related to flavonoids compounds [95]. In addition, *Commiphora leptophloeos* demonstrates antioxidant action in DPPH and superoxide radical scavenging assays, associated with the presence of polyphenols such as rutin, vitexin, and quercetin diglycosides [96]. With regard to the *Pachira aquatic* species, studies indicate that the phenolic fractions of seed have great antioxidant potential, as measured by oxygen radical absorption capacity (ORAC) and trolox equivalent antioxidant capacity (TEAC) assays [97]. Furthermore, the extract fractions of the fruit of *Libidibia ferrea* have shown antioxidant efficacy, increasing glutathione levels and reducing MDA levels [98].

For the group of plants intended for afforestation, *Moringa oleifera* has a great antioxidant action, studies with some fractions of leaves of this species have shown that this activity is related to the compounds kaempferol 3-O-rutinoside, quercetin 3-O-(6″-malonyl- glycoside), kaempferol 3-O-glycoside and quercetin derivative [99]. The *Hymenaea courbaril* species also exhibits antioxidant action with the hydroethanolic extract of its seeds, with flavones as the major compound and possibly responsible for this action [100]. In addition, the methanolic extract of flowers of the *Plumeria rubra* species has a high antioxidant action, eliminating DPPH, FRAP, metal chelating, hydrogen peroxide, and superoxide nitric oxide radicals [101]. Finally, the fruit extract of the *Adansonia digitata* species due to phenolic compounds, inhibiting α-glucosidase [102].

3.4 Anti-Inflammatory Activity

With regard to the anti-inflammatory action of these plants, great potential is evidenced, highlighting the species *Delonix regia* from the gardening group [103]. This, when significant anti-inflammatory activity of *Delonix regia* was observed using the ethanolic extract of its leaves in an *in vivo* model, with a reduction in the edema developed for experimentation [103].

The *Mangifera indica* species of the fruit group also has a great anti-inflammatory action, studies indicate that this effect has been shown to prevent or mitigate inflammation and other symptoms associated with chronic intestinal diseases, colon cancer, leaky gut and constipation through the suppression of pro cytokines, in addition to improving intestinal health [104]. Furthermore, a study carried out by Oliveira et al. (2017) demonstrates that the essential oil of this species is able to reduce edema in a murine model [105]. The species *Spondias mombin*, on the other hand, has shown great action in combating inflammation in murine models [105]. A study carried out by Abiodun, Nnoruka and Tijani (2020) showed the extract of the seeds of this species as a reducer of inflammation [78]. Still, Gomes et al. (2020) demonstrated the anti-inflammatory potential of the hydroethanolic extract with a significant reduction of SOD, MDA, IL-1β and TNF-α [106]. Another species of the fruit group with great anti-inflammatory power is *Malpighia emarginata*. Dias et al. (2014) demonstrated in a study with mice that only the ingestion of fruit juice of this species was able to reduce triglyceride levels, increasing the IL-10/TNF-α ratio in adipose tissue, in addition to acting to reduce levels of JNK (c-Jun N-terminal kinase), responsible for regulating the cell self-destruction process [107]. The species *Prunus subg. Cerasus* also exhibits great anti-inflammatory ability due to cyanidin-3-glucoside present in the fruit and linoleic acid in the seeds, these compounds were able to protect the gastric mucosa against lesions induced by HCl/EtOH and reduce pro-inflammatory cytokines TNF-alpha and IL-6 and increase levels of the anti-inflammatory cytokine IL-10 [108]. In this sense, the species *Anacardium occidentale* also exhibits anti-inflammatory properties, in a murine colon inflammation model, the seeds of this species were able to increase the levels of anti-inflammatory cytokines, in addition to activating the nuclear factor (NF) pathway. -kB, in addition, in an *in vitro* model, the leaf extract of this species was able to inhibit the release of TNF - α and IL-1 β in cells stimulated by LPS [83-84].

With regard to the group of medicinal plants, the anti-inflammatory action of *Artemisia vulgaris* is linked to the normalization of the serum lipid profile, increased activity of paraoxonase-1 and decreased serum levels of malondialdehyde, nitric oxide and tumor necrosis factor-α. proven by lipoxygenase inhibitory activity assay (LOX) and “Cotton Pellets Granuloma Method” [109]. Furthermore, the species *Plectranthus amboinicus* demonstrates inhibition of DNA-binding activities, binding of AP-1 to its consensus DNA sequence, decrease in carrageenan-induced paw edema, and significant increase in IgG, IgM, and lysozyme activity in rats, related to the presence of rosmarinic acid, shimobashiric acid, alvianolic acid L, rutin, thymoquinone, quercetin [110]. Another species that demonstrates anti-inflammatory action is *Mentha piperita*, exhibiting significant results in reducing edema in a murine model, without inducing cytotoxicity [111]. Anti-inflammatory effects were also observed for the extract of the *Curcuma longa* species, demonstrating a reduction in the number of leukocytes, neutrophils and eosinophils, a protective effect related to phospholipase A2 and total protein in several inflammatory disorders, in addition to reducing the rates of IgE, IL- 4, IL-17 and interferon gamma [90]. Still, the *Alternanthera brasiliana* species also demonstrates anti-inflammatory action, reducing nitric oxide and the production of pro-inflammatory cytokines, decreasing levels of inflammatory infiltrate when evaluated in an *in vivo* model [91]. The anti-inflammatory action was also observed for the species *Bryophyllum pinnatum*, promoting the reduction of the regulation of the Toll-like and kappa receptor, in addition to the expression of the nuclear factor B p65 gene, reducing pro-inflammatory and oxidative mediators, chemokines and molecules of cell adhesion [112].

Some species of the group of native plants presents proven anti-inflammatory action, a polysaccharide in the leaf extract of *Handroanthus albus*, capable of reducing the leukocyte infiltration induced by acetic acid in the peritoneal cavity and showed activity antiedematogenic, decreasing mechanical allodynia and myeloperoxidase activity in the carrageenan-induced paw edema model [79]. Another species with this potential is *Commiphora leptophloeos*, through the extract of its leaves it was evidenced anti-inflammatory action related to the modulation of the cytokine level, decrease of TNF-α, increase of IL-10 *in vivo* and also the inhibition of the production of nitric oxide RAW 264.7 activated by LPS [113]. Furthermore, the species *Aspidosperma pyrifolium* has been highlighted as a possible anti-inflammatory, in a study carried out by Lima et al. (2017) the action of the extract of this species was verified in a murine model of envenoming, the results showed a reduction in cell migration to the peritoneal cavity, and likewise the envenomed animals also showed a reduction in edema, infiltration of inflammatory cells and vasodilation in the lungs [95]. In addition, the *Triplaris gardneriana* seed extract also has anti-inflammatory action acting as a modulator in the degranulation of human neutrophils and in the activity of scavenging free radicals, related to the presence of flavonoids [114]. *Libidibia ferrea* also exhibits anti-inflammatory action through the extract and fractions of its fruit, acting in the reduction of leukocyte migration [98]. Another species with this action is *Mimosa caesalpiniifolia*, acting in the modulation of COX-2 and TNF-α expression, attenuating the induced lesions in a murine model [115].

The group of plants for afforestation also has some species with anti-inflammatory characteristics, as is the case of *Moringa oleifera* [116]. Studies indicate that the seeds of this species have a polysaccharide called MRP-1 that exhibits significant effects on inflammatory processes, inhibiting the production of nitric oxide and TNF-α induced by LPS [116]. In addition, the *Gliricidia sepium* species demonstrates anti-inflammatory action, reducing the number of inflammatory cells, and the expression of IL-1β and IL-6. This activity is related to flavonoids, saponins and tannins present in the leaves [117].

4. CONCLUSION

The present study demonstrates the great medicinal potential of the species present in the Horto Municipal de Sobral - CE, Brazil, showing the antimicrobial, antiparasitic, antioxidant, anti-inflammatory and antinociceptive action. Some of the species like *Moringa oleifera* exhibit all these properties, becoming a model for studies. Thus, the raised species have potential for the development of new therapeutic alternatives, whether in the development of a new drug from extracts and essential oils, or even through the enhancement of existing drugs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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