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Review Article

The Potential Effects of Species *Ocimum basilicum* L. on Health: A Review of the Chemical and Biological Studies

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ABSTRACT

Ocimum basilicum Linn is a plant widely found throughout Brazil, popularly known as "Manjerição", it is widely used by the world for medicinal purposes as an agent against rheumatism, headache, hepatitis, and as a diuretic. This research was carried out using databases for thesis, dissertations databases, and articles from indexed journals. This is an integrative literature review, to answer the question: "Does the species *Ocimum basilicum* have biological effects/activities?". Searches were performed in the National Library of Medicine (PubMed), Virtual Health Library (VHL), CAPES, and Scopus journals, in Portuguese and English. A morphometric study of *O. basilicum* leaves was found in the literature. Analyzes revealed different morphological and anatomical patterns. The study of morphology is important in the medicinal activity of the plant since the secondary metabolites in plants are affected by different biotic and abiotic stresses. Thus, stress conditions affect secondary metabolites or so-called active ingredients and other compounds that plants produce, which are often the basis of their medicinal activity. According to the literature, several classes of secondary metabolites were found, such as anthraquinones, flavonoids, terpenoids, and others in the leaves of the species. The recent pieces of evidence indicate that secondary metabolites of the species *O. basilicum* have proven biological activities in antimicrobial, antifungal, antioxidant, allelopathic and biocide

Key words: Manjerição, Bioactivity, Oil essential, Lamiaceae, Alfavaca.

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INTRODUCTION

Many plant species have been used for medicinal purposes in the search for treatment and cure of diseases, a factor that has empirically expanded throughout the world, passing from generation to generation.[1] In this perspective, human beings have shown interest in their well-being and quality of life, motivating the general population and the scientific community to seek and identify new substances from plant species that are beneficial to the human body.[2]

In this context, species belonging to the Lamiaceae family have the potential for obtaining essential oils, which have several biological functions in folk medicine, being used to treat burns, headache, colic, fever, as well as reports of anti-flu, insecticide, repellent activities, antibacterial and fights intestinal parasites.[3]

According to Paton (1992), the genus *Ocimum* contains about 30 species found in the tropics of the Old and New World. Some species are widely cultivated in more temperate regions, presenting medical and culinary applications.

Such substances found in this genus have several biological activities including antimicrobial, antioxidant, analgesic, anti-inflammatory, diuretics, anthelmintics, antibacterial and antifungal. In addition to the recognized entomotoxic potential, they serve as an alternative strategy for the chemical control of *A. aegypti*.[4-8]

In this sense, it is important to highlight the relevance of conducting studies with different genera of plants to assess their potential regarding their biological activities, such as antioxidant, microbiological, and cytotoxicity, to complement the proof of their phytotherapeutic potential of the species. Therefore, the present study aims to collect information about the pharmacological effects of the species *Ocimum basilicum* Linn.

MATERIALS AND METHODS

This is an integrative literature review. A type of study that according to Souza *et al.*[9] it is characterized by the synthesis of evidence and critical evaluation with methodological rigor to integrate the different results to promote understanding of the current state of a given subject and identify gaps that can motivate future studies.

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The construction of this method consists of six fundamental steps: 1) elaboration of the guiding question; 2) search or sampling in the literature; 3) data collection; 4) critical analysis of selected studies; 5) discussion of results; 6) presentation of the review.

For the guiding question, the PICO strategy was used, an acronym for P: problem (types of biological effects of the species *Ocimum basilicum*); I: intervention (*Ocimum basilicum*); C: comparison/control (non-intervention); O: outcome (use of the species for various biological purposes) and it was consolidated in There is evidence that the use of the species *Ocimum basilicum*.

The sampling selection criteria are essential for the reliability of the results, thus, to answer and explain the effects of therapy presented in the literature, the descriptors/keywords in English were used: "*Ocimum basilicum*", "biological effects", " health" and "Chemical composition". In addition, the Boolean operators "AND" and "OR" were added, according to the combination of three alternate descriptors in the search strategies of each database.

The electronic databases consulted were: National Library of Medicine (PubMed), CAPES Journals, and Scopus. Inclusion criteria: articles published from 2000 to 2021, full text, English, Russian or Spanish, primary studies with grade A and B recommendation according to the "Oxford Center for Evidence-based Medicine - Levels of Evidence". Exclusion criteria were: duplicated articles between databases, animal studies, and articles that do not meet the proposed objective.

For a critical analysis of the results, the levels of evidence of the Oxford Center for Evidence-based Medicine-Levels of Evidence were considered, with its last update from March 2009 that enabled the organizational structure of the studies in a hierarchical manner according to their methodological rigor.[9] The levels of evidence can be identified according to Table 1.

Finally, the discussion of the results was carried out from the identification and critical analysis of the contributions and limitations of the studies for the understanding of the potential use of the genus *Ocimum* in biological activities.

SPECIES FROM THE GENUS *OCIMUM*

For the production of medicinal, aromatic, and spice plants it is necessary to evaluate genotypes based on agronomic, phytochemical, and pharmacological parameters for the development of production technologies to obtain enough raw material in standardized quantities.[11]

According to Paton,[12] the genus *Ocimum* contains over 30 species found in the tropics of the Old and New World. Some species are widely cultivated in more temperate regions, presenting uses in culinary and folk medicine.

Plants of this genus are perennial, with an herbaceous or shrubby habit, aromatic with glabrous, pubescent or tomentous stems, with simple or starry trichomes; its leaves are opposite, simple, petiolate, sometimes subsessile, green; loose or congested inflorescence, whorls with 6 flowers and bracts of varying sizes; the flowers are pediceled hermaphrodites presenting a bilabiated calyx, with a rounded, concave upper lip, arising over the tube, with a bilabated corolla, tubular inserted or not in the calyx, glabrous or hairy, white, greenish-white, pink or slightly purple, its four stamens may be all fertile or two sterile exertions, occasionally the upper pair with hairy appendix or glabrous near the base, anthers dorsifixed, the ovary is glabrous or sparsely hairy, tetralobed, with the stigma bifid at the apex; the ovaries are glabrous or sparsely hairy, sometimes brown to black mucilaginous.[13]

The genus *Ocimum* includes species of "basil" (common name in English for several species of *Ocimum*), widely cultivated as aromatic herbs, probably best known being *O. basilicum*.[14]

OCIMUM BASILICUM LINN BOTANICAL DESCRIPTION

Basil (*Ocimum basilicum* L.) according to Rodriguez *et al*.[15] is a medicinal and aromatic plant, native to India. It can be called common basil, which is a familiar species. The most densely cultivated Lamiaceae are cultivated in Brazil. Chenni *et al*.[16] in their report, it is stated that after the arrival of immigrants, the Italians, the cultivation of these plants began to constitute a very strong culinary tradition.

The characteristic of this species is that it presents an annual or perennial cycle, depending on where it grows or according to agronomic characteristics. Its stem is straight and branched. According to Simon,[17] and Mathias,[18] it can reach 50 to 100 cm in height. Its leaves vary in color, in shades of green or purple, they can be smooth or wavy. The flowers are very small and arranged in vertical branches, usually in groups of three, maybe white, lilac or red. The basil of green leaves is the most famous and most cultivated, the rarest and the most are the red leaves.[17]

Traditionally, basil has been used as a medicinal plant in the treatment of various ailments, such as headaches, coughing, diarrhea, constipation, warts, worms, and kidney malfunction,[19] Externally, basil can be used as an ointment for insect bites, and its oil is applied under the skin to treat acne.[20]

CHEMICAL CONSTITUENTS FROM THE SPECIES *OCIMUM BASILICUM* LINN

The chemical composition of *O. basilicum* essential oil may vary in its constituents, according to the geographical area from which it is acquired.[21] Due to the high variability of the chemical structure of *O. basilicum*, it is considered polymorphic.[22] In the study conducted by Pripdeevech *et al*.[23] they used GC-MS to analyze and compare the chemical composition of essential oils extracted from the variation of *O. basilicum*, popularly known as Thai Basil and *O. basilicum*. The dominant compounds of the oil of *O. basilicum* var. was found to be methyl chavicol (81.82%), β-(E) -ocimene (2.93%), and α-(E) -bergamothene (2.45%), while the dominant compounds in *O. basilicum* were linalool (43.78%), eugenol (13.66%) and 1,8-cineole (10.18%) predominantly.

The composition of the essential oils also varies within the country. Essential oils result from the secondary metabolism of plants, normally formed in specialized cells or groups of cells.[24] And they can vary depending on climatic parameters and agronomic factors, such as fertilization, irrigation, and, especially, the stage of development in the plant during harvest. The compounds found in the literature can be observed as shown in Table 2

There is a significant difference in the composition of *O. basilicum* in northern and southern India. The presence of methyl eugenol and methyl chavicol as the predominant constituent in the essential oil is peculiar to the Western Ghats of Northwest Karnataka and the composition varies even more in the rest of the southern part of India. These quantitative and qualitative variations in composition must be credited to the geographical, climatic, and soil conditions that exist in the southern parts of India.[21]

BIOLOGICAL ACTIVITIES

The species *O. basilicum* is used worldwide for medicinal, culinary, and religious purposes. Reports prove that the species in question is used for the treatment of various illnesses, from the treatment of cough, headache, worms, and diarrheal symptoms.[25] Basil polysaccharides have been used to treat cancer.[26] In addition to its pharmacological effect, the species

Table 1: Levels of Scientific Evidence according to the Oxford Centre for Evidence-Based Medicine classification.

Recommendation degree	Levels of evidence	Description
A	1[a]	Systematic review of randomized controlled clinical trials
A	1B	Randomized controlled clinical trial with narrow confidence interval.
A	1C	Therapeutic results of the "all or nothing" type
B	2[a]	Systematic Review of Cohort Studies
B	2B	Cohort Study (including lower quality Randomized Clinical Trial)
B	2C	Observation of therapeutic results (outcomes research) Ecological Study.
B	3[a]	Systematic Review of Case-Control Studies
B	3B	Case-Control Studies
C	4	Case Reports (Including lower quality cohort or case-control)
D	5	Expert opinion devoid of critical assessment or based on basic matters (physiological study or study with animals)

Adapted from Nobre M, Bernardo W. Evidence-based clinical practice. Rio de Janeiro: Elsevier.[10]

Table 2: The main constituents from *O. basilicum*.

Compound	Formula	Molecular Weight (g/mol)	PubChemical
Linalool	$C_{10}H_{18}O$	154.25	6549
Estragole	$C_{10}H_{12}O$	148.2	8815
Geraniol	$C_{10}H_{18}O$	154.25	637566
Bergamotene	$C_{15}H_{24}$	204.35	6429302
Methyl eugenol	$C_{11}H_{14}O_2$	178.23	7127
Eugenol	$C_{10}H_{12}O_2$	164.2	3314
α-Cadinol	$C_{15}H_{26}O$	222.37	6431302
Cyclohexanemethanol	$C_7H_{14}O$	114.19	7507
Methyl cinnamate	$C_{10}H_{10}O_2$	162.18	637520
α- Terpineol	$C_{10}H_{18}O$	154.25	17100
Linalyl acetate	$C_{12}H_{20}O_2$	196.29	8294

Fonte: Chenni *et al.*[16] with adaptations.

O. basilicum is widely used in cooking. This plant is used to spice up Italian and Greek cuisine, being quite popular, especially in southern Europe.[27]

ANTIMICROBIAL ACTIVITIES

Recently, the antimicrobial activities of medicinal plants are being increasingly studied across the globe, and in this context, antimicrobial resistance has become a recurrent global problem, which justifies the demand for alternative and/or newer antimicrobial drugs to treat and eradicate different infectious diseases. The antimicrobial activity of basil is evident by its potent antibacterial, antifungal, antiviral and antiparasitic activities, attributed to the presence of several bioactive compounds.[28-30]

In the study conducted by Moghaddam *et al.*[31] the essential oil of *O. basilicum* leaves was studied against gram-negative and gram-positive bacteria, including *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*. In which the Minimum Inhibition Concentration (MIC) and Minimum Bactericidal Concentration (MBC) were identified. For *P. aeruginosa*, the maximum zones of inhibition were observed by agar disk diffusion tests. The *S. aureus* bacterium presented zones of inhibition of 29.20-30.56 mm and *E. coli* 17.48-23.58 mm. For gram-positive bacteria, the MIC's were: *S. aureus* 18 µg / mL and for gram-negative bacteria the MIC's were: *E. coli* and *P. aeruginosa* were 18-9 µg / mL.

In another study, alcoholic, hydroalcoholic, and aqueous extracts of the species *O. basilicum* were evaluated, which were tested against pathogenic *Escherichia coli*, *Staphyloccocus aureus*, *Streptococcus cricetus*, and *Candida albicans*, and the diameter of the inhibitory zone was the indicator for evaluating the antimicrobial activity. For all bacteria tested, the extracts showed satisfactory microbiological activity.[32-34]

According to published articles, the species in question demonstrates broad antimicrobial activity against various pathogenic strains of bacteria, fungi, and viruses. These findings support the fact that the species *O. basilicum* may be useful as an antimicrobial.

In the study by Issazadeh *et al.*[35] the stem of *O. basilicum* was tested against *Candida albicans*, in which it presented a significant antifungal action, suggesting that it can be used as an antimycotic agent.

The essential oil extracted from *O. basilicum* exhibited antifungal activity against *Aspergillus fumigatus*, *A. niger*, and *Penicillium chrysogenum*.[36] Ahmad *et al.*[34] found that the methanolic extract of *O. basilicum* has significant activities against phytotoxic substances and fungi. Out of the eight strains of pathogenic fungi tested, *Aspergillus flavus*, *A. niger*, *A. fumigates*, *Penicillium*, *Rhizopus solani* and *Alterneria alternata* showed significant inhibitory action, while *Candida albicans* and *Curvularia lunata* were less efficient. The antifungal action of the aqueous extract of *O. basilicum* on *Sclerotium rolfsii* was noted.[37] The essential oil of *O. basilicum* has been reported to prevent *Aspergillus flavus* growth and aflatoxin production.[38]

Herbal antiviral drugs are becoming increasingly popular due to various factors such as the unavailability of suitable drug candidates, increasing resistance to antiviral drugs, and several emerging and re-emerging viral pathogens.[40]

ANTI INFLAMMATORY ACTIVITY

The anti-inflammatory action of the *O. basilicum* species is attributed to compounds such as α-bergamothene, α-cadinol, linoleic acid, estragole, methyl cinnamate, and methyl eugenol.[46] This activity is due to the inhibition of pro-inflammatory mediators along with stimulation of anti-inflammatory cytokines.[47] The plant extract suppresses the production of pro-inflammatory cytokines, including TNF-α, IL-6, and IL-β gene expressions.

In an *in vitro* assay, this plant extract also suppressed the production of NO (nitric oxide) and iNOS (inducible nitric oxide synthase).[48] Similarly, the ethanol extract of *O. basilicum* leaves exhibited *in vitro* anti-inflammatory activity in RAW 264.7 macrophage cells stimulated by LPS, decreasing NO production.[49] The essential oil of *O. basilicum* also exhibited anti-inflammatory activity by inhibiting the lipoxygenase enzyme (98.2%) at low concentrations.[50]

ANTINEOPLASIC ACTIVITY

O. basilicum extract can be considered a potent cancer preventive agent due to its ability to induce drug detoxification enzymes such as glutathione S-transferase and DT-diaphorase.[51] Abd El-Azim *et al.*[52] also proved that *O. basilicum* extracts exhibited a strong cytotoxic effect against colon carcinoma (HCT116) and liver cell lines (HEPG2) due to the presence of phenolic compounds.

The extract from the leaves of *O. basilicum* exhibited cytostatic effects by reducing cell growth of the human breast cancer cell line (MCF-7), indicating a potential therapeutic action against human breast cancer.[53] Fractions of the methanol extract of *O. basilicum* have been reported to induce apoptosis in leukemia cells after activation of the JNK pathway. The excellent result obtained with these fractions may be due to the presence of epicatechin and cinnamic acid derivatives.[54]

BIOCIDAL AND INSECTICIDAL ACTIVITIES

Phytochemical studies play a key role in the use of medicinal plants. Allied to the development of technologies, they become important tools in the discovery of new substances that are effective for therapeutic purposes and for the control of pests that cause various pathologies for humans. The mosquitoes of the *Culicidae* family are the ones that have attracted the most attention from public health.[55]

The research of chemical compounds derived from plants, for the development of botanical insecticides, is another important line of study for mosquito control. In this context, the search for safe alternatives for vector control is extremely important for public health. The discovery of new substances that are effective in preventing pests and offer safety and economic feasibility applicable to integrated insect control programs to eliminate diseases caused by them, in addition to having a low environmental impact.[56]

Oils of the *Ocimum* genus are studied to evaluate their repellent and larvicide activity against flies and mosquitoes, vectors of diseases, and pests. In the study by Mahmoud *et al*.[57] the concentration of *O. basilicum* oil necessary to cause the death of *A. aegypti* larvae ranged from 113 ppm to 283 ppm. The repellent properties can be attributed to the compounds d-limonene, myrcene, and thymol, while eugenol and methyl-chavicol are found in the plant's oil and have proven larvicidal activity.

The essential oil extracted from the leaf of *O. basilicum* can be used as a safe, effective, and naturally available larvicide agent against mosquitoes.[58] In the study by Rodriguez *et al*.[59] *O. basilicum* essential oils were studied for their insecticidal activity against acanthoscelids, common bean pest (*Phaseolus vulgaris*), which was applied topically to beans, hindering the development of *A. obtectus*. This led to a significant decrease in the number of damaged beans. The potent insecticidal activity of *O. basilicum* essential oil can be used as an environment-friendly substitute for conventional insecticides available on the market.

ANTIOXIDANT ACTIVITY

Studies on free radicals and the development of new methods to assess antioxidant activity (AA) have increased considerably in recent years. The discoveries of the harmful effect of free radicals on cells and their relationship with certain diseases, acting as a cause or aggravating factor, boosted the search for new substances capable of preventing or minimizing oxidative damage to living cells.

In the study of Silva *et al*.,[60] the antioxidant activity was evaluated using different methods, including DPPH radical scavenging activity, ferric reducing power (FRAP), iron ion chelating power, inhibition of lipid peroxidation (TBARS), NO radical scavenging, and oxidative hemolysis inhibition. Quantification of total phenols and flavonoids carried out. The results with the *Ocimum basilicum* spices in the DPPH test showed activity (82.01%), FRAP (321.12 uM ET and iron chelating activity (94.18) and for the Cinnamomum zeylanicum spice in the TBARS test (18.52%) evaluated by different methods and mechanisms of inactivation of free radicals and according to the evaluation of genotoxicity by the Allium strain test the spices do not present genotoxic effects.

CONCLUSION

It is possible to show that the species of *Ocimum basilicum* L. has biological properties of high scientific value. Some of the proven therapeutic activities, such as: Antimicrobial, antifungal, larvicide, insecticide, antiparasitic, antioxidant, and antineoplastic. Mainly concerning activities related to antimicrobial, antifungal, antioxidant, allelopathic and biocide.

Detailed information in the literature on *O. basilicum* reveals that this species has widespread use in many regions of the world and has broad pharmacological action proven in scientific research. That is, they concluded that the species *O. basilicum* has a high pharmaceutical value, especially in its anti-inflammatory activity.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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