LUMEN ET VIRTUS
ISSN: 2177-2789

BIOLOGICAL PROPERTIES OF PEQUI OF INTEREST TO HUMAN HEALTH: A NARRATIVE REVIEW

https://doi.org/10.56238/levv15n43-078

Submitted on: 20/11/2024 **Publication date:** 20/12/2024

Carolinne Alves Mota[1], Esther Alves Marinho[2], Gustavo Rocha Ramos[3], Luan Gabriel Souza Martins[4], Rebecca Alves Marinho[5], Brendha de Almeida[6], Davi Lopes Schmidt[7], Eduarda Lessa Lopes Barbosa[8], Natália Alves Almeida Mendes[9], Robson Rosa

[1] Undergraduate student in MedicineState University of Montes Claros
E-mail: carolinne.mota@hotmail.com
ORCID: https://orcid.org/0000-0003-3852-6211
LATTES: http://lattes.cnpq.br/8431347184011159
[2] Medical Student
State University of Montes Claros
E-mail: alvesmarinhoesther@gmail.com
ORCID: https://orcid.org/0009-0004-9633-5151
LATTES: http://lattes.cnpq.br/8097119665063878
[3] Graduating in Medicine
State University of Montes Claros
E-mail: gustavorramos.gr@gmail.com
ORCID: https://orcid.org/0009-0009-7652-1543
LATTES: http://lattes.cnpq.br/6167493897399931
[4] Graduating in Medicine
State University of Montes Claros
E-mail: luangabribig@outlook.com
ORCID: https://orcid.org/0009-0001-7876-2561
LATTES: http://lattes.cnpq.br/3074685571149240
[5] Medical Student
State University of Montes Claros
E-mail: rebeccaalvesmarinho@gmail.com
ORCID: https://orcid.org/0009-0004-8751-7172
LATTES: http://lattes.cnpq.br/0954725982792195
[6] Medical Student
State University of Montes Claros
E-mail: brendhadealmeida19@gmail.com
ORCID: https://orcid.org/0009-0008-8313-6646
LATTES: http://lattes.cnpq.br/0778429150693568
[7] Graduating in Medicine
State University of Montes Claros
E-mail: schmidtldavi@gmail.com
ORCID: https://orcid.org/0009-0006-1963-4603
LATTES: http://lattes.cnpq.br/0681301595988001
[8] Medical Student
State University of Montes Claros
E-mail: eduardalessalb@gmail.com
ORCID: https://orcid.org/0009-0000-0036-4726
LATTES: http://lattes.cnpq.br/1737283828604733
[9] Medical Student
State University of Montes Claros
E-mail: natalialalmendes@gmail.com
ORCID: https://orcid.org/0009-0000-4118-6890
LATTES: http://lattes.cnpq.br/2081955304588770

Egêa[10], Stella Andrade Damasceno[11], Vinicius Bérgamo Dias[12], João Afonso Mendes Moreira[13], Laissa Geovana Cardoso Pereira[14] and Waldemar de Paula-Júnior[15]

ABSTRACT

Objective: To describe the immunological, anti-inflammatory, analgesic, antifungal, antibiotic and disease control impacts resulting from the use of Caryocar brasiliense in the fields of science and medicine. Method: Qualitative study of narrative review carried out from searches in six indexing databases, with the last 24 years as a reference period. Studies developed in humans, animals or cell culture, published in Spanish, English or Portuguese, were considered. A total of 281 articles were found, and after excluding duplicate, triplicate, or constant works, 164 remained. After analysis of titles and abstracts, the works considered not relevant to the topic addressed were excluded, leaving a total of 18 articles. Results: Of the 18 articles analyzed, 44.44% point to the impacts of Caryocar brasiliense on anti-inflammatory and analgesic activity, 22.22% on antibiotic activity, 16.67% highlight the effects on disease control and 11.11% the antifungal effects. Regarding the immunological implications of C. brasiliense, only 1 article pointed to this action. Conclusion: This study addresses the various benefits that the herbal use of pequi-derived components can provide to human health. However, there is still a lack of clinical trials to better evaluate the impacts of these plant compounds, requiring future research that explores their mechanisms of action and therapeutic applications.

Keywords: Human Health. Phytotherapy. Herbal Medicine. Plant Extracts. Natural Product.

[10] Graduating in Medicine
State University of Montes Claros
E-mail: robson.egea@gmail.com
ORCID: https://orcid.org/0009-0000-0817-7247
LATTES: http://lattes.cnpq.br/9152006235032613
[11] Medical Student
State University of Montes Claros
E-mail: stelladamasceno25@gmail.com
ORCID: https://orcid.org/0009-0001-6002-9820
LATTES: http://lattes.cnpq.br/0222961043889192
[12] Graduating in Medicine
State University of Montes Claros
E-mail: dias.viniciusbergamo@gmail.com
ORCID: https://orcid.org/0000-0001-7580-1169
LATTES: http://lattes.cnpq.br/6845365418503114
[13] Graduating in Medicine
State University of Montes Claros
E-mail: contato.joaoafonso@gmail.com
ORCID: https://orcid.org/0009-0001-9775-8082
LATTES: http://lattes.cnpq.br/0052246599630447
[14] Medical Student
FIP Guanambi AFYA
E-mail: laissagcardosop@gmail.com
ORCID: https://orcid.org/0009-0009-6888-4926
LATTES: http://lattes.cnpq.br/5517360948705802
[15] Dr. in Pharmaceutical Sciences
Federal University of Ouro Preto
E-mail: waldemar.junior@unimontes.br
ORCID: https://orcid.org/0000-0001-7300-2638
LATTES: http://lattes.cnpq.br/9467770538683733

INTRODUCTION

Caryocar coriaceum Wittm, or *Caryocar brasiliense*, is a plant typical of the Brazilian cerrado and neighboring countries of Brazil (SARAIVA et al., 2015). Popularly known as pequi tree, this species is one of the plants best used by man, especially by local inhabitants who live in regions populated by this species, such as the Southeast, Northeast and Midwest regions of Brazil (COSTA; ARAÚJO; LIMA-VERDE, 2004). This is justified by the fact that *Caryocar brasiliense* stands out for its numerous uses in cooking, since it has an edible fruit, the pequi, of the oilseed type (NETO et al., 2017), but also potential uses in modern medicine.

In this sense, there are records that derivatives of the pequi tree, such as bark, leaves, root, and fruit, have been exploited for centuries by the indigenous peoples of Brazil, in order to provide relief against various diseases (OLIVEIRA et al., 2016). The oil extracted from the pulp and seed of the pequi, whose high concentration of fatty acids, unsaturated fats and antioxidant vitamins provides anti-inflammatory and anesthetic effects, mainly, is widely explored today both by "popular knowledge" and by the most innovative scientific parameters of the pharmaceutical industry (FIGUEIREDO et al., 2016).

Because it is rich in oleic acid, *C. brasiliense* is an important natural source of attributes of exploratory potential in the field of health, as this compound, in addition to other substances present in the fruit and in other compositions of the plant, is an unsaturated fat whose use is established as an adjuvant in antimicrobial, anti-inflammatory, healing treatment and on other fronts of therapeutic use.

In the context of public health, the increase in infectious diseases and inflammatory processes in recent decades underscores the need to explore natural and affordable alternatives for disease control, prevention, and treatment. In this sense, being a native plant and widely available in Brazil, the pequi has therapeutic potential not yet fully explored. In addition, with the advance in the demand for more sustainable management of raw materials for the production of therapeutic formulations, the use of herbal medicines and cosmetics has become an emerging need in the pharmaceutical and medicinal environment, which would also allow valuing the biodiversity of the Brazilian cerrado.

In addition, although there are many studies in the literature that demonstrate the beneficial effects of *C. brasiliense*, especially on its antioxidant potential (AGUILAR et al., 2012; FONSECA et al., 2016; NASCIMENTO-SILVA; NAVES, 2019), data on its antibiotic, antifungal, anti-inflammatory, and immunological mechanisms are still limited and dispersed. Thus, the integration of the main results of existing studies in the scientific literature on the subject would contribute to encourage the sustainable use of pequi and its

conservation, in addition to responding to a gap in the literature, gathering and fully analyzing the medicinal effects of this species.

In this sense, this work aimed to produce a narrative review of the literature on the biological actions of C*. brasiliense derivatives* on the immunological, anti-inflammatory, analgesic, antifungal, antibiotic effects, in addition to their use for disease control, seeking the investigation and compilation of findings aimed at the composition of natural products with the medicinal potentials of this native plant.

METHODOLOGY

This is a qualitative study of narrative review of the literature. Searches were carried out in the following databases: Virtual Health Library (VHL), Cochrane, Google Scholar, LILACS, PubMed and Scielo, using the following descriptors: *Caryocar brasiliense cambess, Caryocar brasiliensis,* Pequi and Pequizeiro - associated with the Boolean operator AND. The study included clinical trials developed in cell culture, animals or human beings, published free of charge in Portuguese, English or Spanish written in the last 24 years. Opinion articles, review articles, book chapters, letters to the editor, comments, dissertations, pilot studies, reviews, theses, monographs, methodological reports, and abstracts of scientific events were excluded. Initially, 281 articles were found, those that were repeated in more than one database had the repetition disregarded, leaving 164. After analysis of titles and abstracts, the works considered not relevant to the proposed theme were excluded, leaving 18 articles in the end. These were, therefore, fully evaluated to compose the present review.

RESULTS

IMMUNOLOGICAL EFFECTS

Of the 18 articles selected for full analysis, only 1 studied the possible immunological actions of *Caryocar brasiliensis*, which belongs to the Brazilian literature and was published in 2022 (Chart 1). The only constituent evaluated was pequi pulp oil, in a nanoencapsulated pharmaceutical formulation. The work obtained positive results regarding the immunological effects of the pequi.

Table 1: Immunological effects of *Caryocar brasiliense*

Authors/Year	Objective	Key findings
SILVA et al., 2022	To demonstrate the effect of pequi oil on women with knee osteoarthritis through the development of a pharmaceutical formulation containing nanoencapsulated pequi pulp oil (PeONC) and to evaluate	PeONC was presented as a stable, safe formulation without irritability or toxicity for topical use in humans. In 21 days of treatment with PeONC, there was an increase in strength and total knee amplitude, body balance and quality of life, in

	its effects on pain and functionality in these patients.	addition to reducing the risk of falls, probably related to the main fatty acids present in pequi oil and their associated immunomodulatory effects. Treatment with PeONC increased the strength of the knee flexor and extensor muscles, their full range of motion, and reduced knee instability, pain, swelling, and locking.

Source: prepared by the authors

DISEASE CONTROL EFFECTS

Of all the articles analyzed in this study (18), 16.67% (3) express the effects on disease control of *Caryocar brasiliense*. All of these studies are Brazilian and were published from 2020 to 2023 (Chart 2).

Chart 2: Effects on disease control of *Caryocar brasiliense*

Authors/Year	Objective	Key findings
MORAIS et al., 2020	To evaluate the biological effects of hydroalcoholic extract from *Caryocar brasiliense* leaves on the development of aquatic immature stages of A. aegypti.	The hydroalcoholic extract of *Caryocar brasiliense* leaves has a negative effect on the development of Aedes aegypti larvae, especially at higher concentrations, delaying larval development and decreasing the number of emerging adults in a dose-dependent manner. Growth inhibition was dose-dependent, with an increase in concentrations resulting in a decrease in the number of adults.
LIMA et al., 2022	To analyze the larvicidal effect of the aqueous extract of pequi (*Caryocar brasiliense*) on Aedes aegypti.	The results suggest that the aqueous extract of *Caryocar brasiliense*, especially the 40:10 and 20:30 dilutions, are promising in the search for natural compounds with larvicidal activity on Aedes aegypti.
AZEVEDO et al., 2023	The objective of this research was to evaluate, under laboratory conditions, the larvicidal effect of essential oils obtained from FLONA plants such as field rosemary, copaiba, bay leaf, cashew and pequi, in the control of Ae. aegypti .	Pequi oil was tested on Culex *quinquefasciatus* larvae at different concentrations and showed mortality of 25 to 55% of the larvae at doses of 12.5 mg/L and 100 mg/L, respectively. The essential oil of pequi had mortality efficiency equal to that of rosemary (10.3), being lower than cashew (10.7), copaiba (11.0) and bay leaf (16.2).

Source: prepared by the authors

ANTI-INFLAMMATORY AND ANALGESIC EFFECTS

Of the studies analyzed, eight (44.44%) focused on the anti-inflammatory activity of pequi derivatives, with two of them emphasizing mainly the associated analgesic activity (Chart 3). The studies were published between 2008 and 2023. All articles brought positive results when evaluating the anti-inflammatory potential of the fruit of *C. brasiliense*, associating it mainly with the content of phenolic compounds and fatty acids found in the pequi.

Table 3: Anti-inflammatory and analgesic effects of *Caryocar brasiliense*

Authors/Year	Objective	Key findings

LOPES et al., 2008.	To determine in vitro the potential of papain and pequi oil as open penetration promoters for diclofenac sodium (DS) through human skin.	The combination of pequi oil and papain showed potentiating performance in intensifying the penetration of diclofenac sodium through the skin.
ROLL, 2018	The aim of this study was to investigate in vivo the antioxidant and anti-inflammatory effects of pequi oil on blood count and DNA damage in healthy young adult and middle-aged elderly mice of both sexes. The animals, aged between 6-7 and 11-12 months, were treated orally for 15 days with pequi oil at a dose of 30 mg/day.	It was observed that the treatment significantly influenced the hematological parameters. Pequi oil significantly increased lymphocytes and decreased neutrophils + monocytes.
BEZERRA et al., 2020	To evaluate the effects of pequi (*Caryocar brasiliense*) and sunflower (*Helianthus annus*) oil supplementation on physiological parameters in piglets in the nursery phase. A total of 180 piglets housed in a commercial farm were used, distributed in three groups (n=60) according to feed supplementation: pequi oil, sunflower oil and negative control.	The results of this study indicate that supplementation with vegetable oils, specifically pequi oil and sunflower oil, had a significant impact on inflammatory parameters of piglets in the nursery phase.
COUTINHO et al., 2020	To evaluate the effects of pequi oil, in free form or loaded in nanoemulsions on the modulation of inflammation in acute lung injury	Treatment with pequi-nanoemulsion completely abolished the increase in inflammatory cells. LPS provocation increased cytokines TNF-alpha, IL-1beta, IL-6, MCP-1 and KC and oral treatment with pequi-NE reduced the levels of these cytokines in lung tissue, Stimulation with LPS also reduced the levels of pulmonary catalase, treatment with pequi-NE and oleic acid-NE restored catalase activity.
JUNIOR et al., 2020	To determine the composition and safe use of Pequi oil from the Cerrado of Campo Grande, and the anti-inflammatory and antinociceptive activities of this Pequi oil were investigated in in vivo models.	Pequi oil, especially at the highest dose (1,000 mg/kg), may reduce leukocyte migration in carrageenan-induced pleurisy, similar to the effect of dexamethasone. In addition, pequi oil showed antihyperalgesic activity and almost completely blocked allodynia.
SILVA et al., 2022	To demonstrate the effect of pequi oil on women with knee osteoarthritis through the development of a pharmaceutical formulation containing nanoencapsulated pequi oil (PeONC) and to evaluate its effects on pain and functionality in these patients.	In the study, there was a reduction in complaints related to the affected knee after treatment, which may be related to the main fatty acids present in pequi oil and their associated anti-inflammatory and immunomodulatory effects. In addition, the treatment reduced knee instability, pain, swelling, and locking.
PINHEIRO et al., 2022	To formulate and characterize pequi oil nanoemulsion (PeNE) to investigate its anti-inflammatory and antinociceptive effects, as well as its biocompatibility in in vitro and in vivo models.	The antinociceptive effect of pequi oil transported by a nanoemulsified system was demonstrated. PeNE (100 or 400 mg/kg) reduced hypernociception by 27 and 40%, respectively, while free pequi oil (100 or 400 mg/kg) reduced it by 40 and 52%, respectively. The control treatments with dipyrone and dexamethasone, a potent anti-inflammatory, showed a reduction in hypernociception by 79 and 96%, respectively

FRACASSO et al., 2023	OBJECTIVE: To analyze the toxicity and anti-inflammatory activity of a pequi pulp residue extract (ERPP) after mechanical extraction of the oil from its pulp.	Inhibition of macrophage phagocytosis in a manner similar to dexamethasone (anti-inflammatory effect). When administered in high doses, no morbidity or significant changes in behavior were observed - only hyperexcitability and hypnosis in the animals.

Source: prepared by the authors

ANTIFUNGAL EFFECTS

Among the articles selected for analysis, 11.11% are related to the antifungal effects of *Caryocar brasiliense*, published in 2015 and 2016, all of which are of Brazilian origin (Chart 4). The studies, in their entirety, revealed the significant antifungal activity resulting from compounds present in the oils extracted from seeds and almonds and in the pequi leaf – such as the crude ethanolic extract, the ethyl acetate fraction and the epicuticular wax.

Table 4: Antifungal effects of *Caryocar brasiliense*

Authors/Year	Objective	Key findings
PASSOS et al., 2002	To describe the antifungal activity of the leaves, the main components of the essential oil of the seeds and the fixed oils of the almond and seed of *C. brasiliensis* on isolates of *C. neoformans var. neoformans* and *C. neoformans var gattii.*	The portions of the leaf, fixed seed and almond oil and essential oils showed significant actions of inhibition of fungal activity.
BREDA et al., 2016	To evaluate the activity of three species of the Brazilian cerrado, one of them being *Caryocar brasiliense*, against phytopathogenic fungi.	The ethanolic extracts of bark and leaves of *Caryocar brasiliense* (pequi) showed significant activity against the growth of phytopathogenic fungi.

Source: prepared by the authors

ANTIBIOTIC EFFECTS

Antibiotic effects were revealed in 22.22% of the articles selected for analysis, published between 2006 and 2022, all of which were of Brazilian origin (Chart 5). The studies evaluated the antibiotic action of the aqueous and ethanolic extracts extracted from the leaf of *Caryocar brasiliense* against the microorganisms *Enterococcus faecalis, escherichia coli, Pseudomonas aeruginosa and Staphylococcus aureus*, proving, in 100% of the articles, the bacteriostatic effect of these substances.

Table 5: Antibiotic effects of *Caryocar brasiliense*

Authors/Year	Objective	Key findings
DE PAULA-JU et al., 2006	To test the effects of hydroethanolic extract of pequi leaves against promastigotes of *Leishmania amazonensis* and some species of pathogenic bacteria and fungi and to investigate the antioxidant property of this extract in comparison to vitamin C and rutin.	The extracts inhibited *P. aeruginosa* and *S. aureus*, but did not perform as well as the recommended antibiotics.

AMARAL et al., 2014.	To evaluate the antimicrobial and antioxidant activities of an extract of *C. brasiliense* (Pequi) obtained by supercritical CO2 extraction.	The supercritical CO2 extract of *C. brasiliense* has antimicrobial activity against all the bacteria tested.
RIBEIRO et al., 2018	To characterize Cerrado leaf extracts for inhibitory effects against *Escherichia coli* and *Staphylococcus spp*. from cattle.	The aqueous and ethanolic extracts of *Caryocar brasiliense* showed inhibitory effects against E.coli and all *Staphylococcus spp*.
ROYO et al., 2022	Perform physicochemical analyses, obtain pollen count for flowering classification, obtain the chromatographic profile and verify the antioxidant and antimicrobial activities in honeys from different locations in Minas Gerais.	Pequi extracts showed antibiotic effects only against some bacteria, such as *S. salivarius* and *S. sanguinis.*

Source: prepared by the authors

The components flavonoids, anthraquins, steroids, alkaloids, saponins and tannins are identified as the main responsible for this activity, by interacting with the membrane and cell wall of the pathogens and thus inhibiting their growth. Similarly, from the ethanolic extract from the leaves of *Berberis vulgaris*, an effective action was demonstrated against *Staphylococcus aureus, Escherichia coli* and *Staphylococcus enteritis*, due to the presence of phenolic components, which proves its function of making the cellular structures of the pathogen unstable, inhibiting the synthesis of proteins, RNA and DNA (EL-ZAHAR et al., 2021).

The study carried out by Royo et al. (2022) analyzed the antibiotic activity of honey produced from Pequi nectar, in which the minimum inhibitory concentration (MIC) and the minimum bactericidal concentration (MBC) of the S*. salivarius, S. sanguinis strains were determined*, an issue that occurs due to the higher acidity of the Pequi, leading to the formation of gluconic acid, an effective antibacterial. However, there is a lack of studies in the literature that analyze the specific efficacy of honey against a greater diversity of bacterial strains, which makes it difficult to analyze this compound.

Only De Paula-Ju et al. (2006) relate the effects of *Caryocar brasiliense* to antibiotic drugs, revealing that ethanolic extracts do not reach the same level of efficacy as drugs. Thus, as also studied through the leaves of *Rhodomyrtus tomentosa*, despite significant bacteriostatic activity, there are still not enough studies capable of confirming this possibility of replacing antibiotics, despite the fact that the simultaneous use with drugs considerably reduces the minimum inhibitory concentration (MIC) of drugs (MORDMUANG et al., 2019).

DISCUSSION

Regarding immunological effects, Silva et al. (2022) demonstrated that nanoencapsulated pequi oil (PeONC) promoted increased strength and total knee range, reduced knee instability, pain, swelling, and locking, and reduced the risk of falls. The

reduction in complaints may be related to the main fatty acids present in pequi oil and their associated immunomodulatory effects. The sample group involved women with osteoarthritis, an autoimmune disease, whose treatment with greater scientific evidence is based on the objective of delaying the progression of the disease (CLEGG et al., 2006). To achieve this end, a group of drugs widely used and with considerably efficient results are immunomodulators, such as methotrexate (WEINBLATT et al., 1985). According to Waitzberg (2009), polyunsaturated fatty acids are present in the group of nutrients capable of modulating the systemic immune and inflammatory response and are mainly associated with a decrease in the intensity of the inflammatory response. What reinforces the immunomodulatory action of pequi is the fact that the main acids present in it are unsaturated fatty acids, mainly oleic acid and palmitic acid, which, as demonstrated by (AFONSO et al., 2016) can regulate the expression of some pro- and anti-inflammatory macrophage markers that modulate the inflammatory process and reduce pain. Thus, although the present review analyzed only one article that addressed the immunomodulatory effects of pequi, it was evidenced that the capacity of this fruit may suggest potential use in a variety of conditions, especially autoimmune and inflammatory diseases, highlighting the need for interdisciplinary research to explore these possibilities.

Regarding the analysis of articles whose focus was disease control, there was a clear demonstration that the aqueous extract of pequi (*Caryocar brasiliense*) has a remarkable capacity to act as a larvicide, especially in the dilutions of 40:10 and 20:30, which showed lethality greater than 90% in 24 hours (LIMA et al., 2022). This action was evidenced against the larva of *Aedes aegypti*, the mosquito responsible for transmitting the Dengue, Zika, Chikungunya, and Yellow Fever viruses to humans (VIEIRA et al., 2023). The hydroalcoholic extract of pequi leaves acts by inhibiting larval development when at concentrations of 400 and 500 ppm, reducing the number of larvae that develop into pupae and the population of adult mosquitoes (MORAIS et al., 2020). *Caryocar brasiliense* oil is an alternative form to commonly used insecticides, which can lose their effectiveness when resistance by mosquitoes emerges, showing mortality of more than 50% of *Culex quinquefasciatus larvae* at a concentration of 100 mg/L (AZEVEDO et al., 2023). The essential oil of java citronella (*Cymbopogon Winterianus*), a plant native to Indonesia, also had an effect on disease control by acting in a similar way to pequi extract on the larvae of the mosquito vector of Dengue, showing significant inhibitory activity on the progression of larvae to the form of adult insects (CANSIAN et al., 2023). In addition, C. *Winterianus* has the ability to act as a repellent, keeping mosquitoes away and avoiding diseases carried by these vectors (ÉDEN et al., 2020).

The potential of pequi compounds in the treatment of inflammatory diseases was evaluated based on the ability of its oil to reduce the level of cytokines such as TNF-alpha, IL-1beta, IL-6 and MCP-1, as the fruit was able to modulate the levels of pro-inflammatory mediators, its possible action in the treatment of these conditions in different foci is highlighted. Its richness in compounds such as palmitic and oleic fatty acids, which can regulate the expression of markers, especially IL-6, TNF-α, and transcription factor NF-kB, was a finding that demonstrated its favorable antagonistic action to the inflammatory process (COUTINHO et al., 2020). As an example attributed to this potential, treatment with pequi oil was effective in increasing joint strength and range of motion and reducing symptoms of knee osteoarthritis by minimizing the level of pro-inflammatory substances related to this joint involvement (SILVA et al., 2022). These results are similar to the evaluation of the herbal formula Danggui-Shaoyao-San (DSS) - known in traditional Chinese medicine -, which also demonstrated benefit in the treatment of knee osteoarthritis from the modulation of the NF-κB signaling pathway with consequent suppression of IL-6 (CHEN et al., 2024).

In addition, the response of cell types involved with inflammation, such as neutrophils, lymphocytes, and monocytes, was investigated after the administration of pequi oil. A decrease in neutrophils and monocytes was observed in groups of mice due to the phenolic content - known to be related to the inhibition of pro-inflammatory compounds - of the pequi pulp (ROLL et al., 2018). Compatible results were found when evaluating an ointment of aqueous extract of the plant *Ocimun basilicum*, which reduced the total cell and neutrophil count in wounds, a finding that was also related to phenolic phytochemicals present in its composition (ZHAKIPBEKOV et al., 2024).

In the group of articles analyzed, there were also tests that measured the effectiveness of pequi in helping to regress symptoms of inflammation. Regarding pain sensation - one of the cardinal signs of inflammation - two of the articles indicated a significant impact of the *Caryocar brasiliense fruit* on pain reduction. The analgesic activity and almost complete blockade of allodynia after administration of pequi oil in in vivo models were highlighted (ARMANDO et al., 2020). This fact was also identified after the use of pequi oil nanoemulsion and free oil in a second study, which exposed the antinociceptive action of the fruit, which provided a pain reduction of between 27 and 52% depending on the dosage of pequi derivatives, with greater relative efficacy associated with free oil. This impact was smaller than the reduction in hypernociception of dipyrone and dexamethasone, which corresponded to 79% and 96%, respectively, but was still considered significant (PINHEIRO et al., 2022). Analogous to both analyses, the pain-reducing effect was

investigated in humans after the administration of black cumin oil or *Nigella sativa* and the results were also positive, which would be linked to the composition of the oil, rich in linoleic acid and oleic acid (FILI et al., 2024), compounds that were also identified in the studies carried out with pequi oil (ARMANDO et al., 2020; PINHEIRO et al., 2022), ratifying its potential in the successive stages of resolving inflammation.

Finally, two studies highlighted the relationship between pequi and already known anti-inflammatory drugs, the first of the articles discussed the interaction between pequi and the administration of diclofenac and the second established a comparison between the potential of the fruit with dexamethasone. Pequi oil, associated with the enzyme papain, was able to increase the penetration coefficient of diclofenac sodium via transdermal, even more effectively than pure pequi oil, which may favor the reduction of side effects and the hepatic first-pass metabolism of the drug (LOPES et al., 2008), therefore, In addition to its anti-inflammatory power, pequi could also help in the action of drugs already known in pharmacology. Regarding the comparisons between the anti-inflammatory effect of *Caryocar brasiliense* fruit and dexamethasone, it was identified that pequi oil inhibited macrophage phagocytosis in a similar way to commercial anti-inflammatory, significantly promoted cell membrane stabilization and was also successful in mitigating IL-6 expression, which was also attributed to phenolic compounds identified in pequi pulp and almond (FRACASSO et al., 2023). Similarly, the herbal properties of Pretty Velvet Rosebud Extract (PVRE) have also been compared with dexamethasone, achieving similar results in attenuating tissue erythema, edema, and inflammatory cell infiltration, a fact attributed to the extract's high polyphenol content (WANG et al., 2023).

The phenolic substances present in *Caryocar brasiliense* were presented as one of the most important protective functions of the plant, thus favoring its effects against pathogenic fungi. The crude ethanolic extract, when studied in the flowers of *Woodfordia fruticosa*, also showed antifungal action by disrupting the structure of its cellular components (NADJA et al., 2021). In the *plant P. granatum*, the ethyl acetate fraction was determined to be significantly favorable to the fight against fungi, due to the phenolic components present in its structure (MENDONÇA et al., 2022). Epicuticular wax, on the other hand, in the cereal *Sorghum bicolor*, resulted in a notable reduction in the growth of anthracnose mycelium, by inhibiting the pathogen's hydrolytic enzymes (XIONG, et al., 2023).

The efficacy of oils extracted from *C. brasiliense seeds and almonds* against *C. neoformans* was significant, with all isolates being inhibited by these compounds. In comparison to this, the anti-fungal action of *Armenia sibirica* almond oil was analyzed,

which proved not only moderate to high activity in all situations, but also a broad spectrum of antifungal action (GENG et al., 2016).

The flavonoid, anthraquin, steroid, alkaloid, saponin, and tannin components of *Caryocar brasiliense* are identified as the main responsible for its antibiotic activity, by interacting with the membrane and cell wall of the pathogens and thus inhibiting their growth. Similarly, from the ethanolic extract from the leaves of *Berberis vulgaris*, an effective action was demonstrated against *Staphylococcus aureus, Escherichia coli* and *Staphylococcus enteritis*, due to the presence of phenolic components, which proves its function of making the cellular structures of the pathogen unstable, inhibiting the synthesis of proteins, RNA and DNA (EL-ZAHAR et al., 2021).

The study carried out by Royo et al. (2022) analyzed the antibiotic activity of honey produced from Pequi nectar, in which the minimum inhibitory concentration (MIC) and the minimum bactericidal concentration (MBC) of the S*. salivarius, S. sanguinis strains were determined*, an issue that occurs due to the higher acidity of the Pequi, leading to the formation of gluconic acid, an effective antibacterial. However, there is a lack of studies in the literature that analyze the specific efficacy of honey against a greater diversity of bacterial strains, which makes it difficult to analyze this compound.

Only De Paula-Ju et al. (2006) relate the effects of *Caryocar brasiliense* to antibiotic drugs, revealing that ethanolic extracts do not reach the same level of efficacy as drugs. Thus, as also studied through the leaves of *Rhodomyrtus tomentosa*, despite significant bacteriostatic activity, there are still not enough studies capable of confirming this possibility of replacing antibiotics, despite the fact that the simultaneous use with drugs considerably reduces the minimum inhibitory concentration (MIC) of drugs (MORDMUANG et al., 2019).

CONCLUSION

The objective of this narrative review was to explore the biological impacts and medicinal properties associated with *Caryocar brasiliense*, focusing on anti-inflammatory, analgesic, antifungal, and antibiotic effects, as well as its efficacy for disease control. Among the main relevant results, 44.4% of the selected studies highlighted the intense anti-inflammatory and analgesic character of pequi, with potent action on cytokines, leukocytes and inflammatory mediators, in addition to the emphasis on its antinociceptive effect. Among the other articles analyzed, antibiotic (22.2%), vector control, with emphasis on larvicidal (16.67%), antifungal (11.11%) and immunological (5.56%) functions, were evidenced. The effects on clinical practice of *Caryocar brasiliense* were compared with drugs used and available on the market, emphasizing an efficacy similar to anti-

inflammatory drugs, however the bacteriostatic and bactericidal actions of the pequi compounds did not reach the same level of drug efficacy.

The present work allowed us to gather theoretical and practical data on a wide diversity of effects of *Caryocar brasiliense*, gathering robust evidence on these benefits, such as anti-inflammatory and analgesic properties, and highlighting areas that lack investigations, such as immunological, antifungal and disease control effects. Thus, the literature review emphasizes the impact of pequi compounds for alternative medicinal use, synthesizing existing research and suggesting new investigative paths, with the need to develop new studies, with a large sample and that analyze the effects of this in the clinical of patients.

REFERENCES

1. Aguilar, E. C., et al. (2012). Paradoxical effect of a pequi oil-rich diet on the development of atherosclerosis: balance between antioxidant and hyperlipidemic properties. *Braz J Med Biol Res, 45*(7), 601-609.

2. Afonso, M. S., et al. (2016). Dietary interesterified fat enriched with palmitic acid induces atherosclerosis by impairing macrophage cholesterol efflux and eliciting inflammation. *Journal of Nutritional Biochemistry, 32*, 91–100.

3. Amaral, L. F. B., et al. (2014). Caryocar brasiliense supercritical CO2 extract possesses antimicrobial and antioxidant properties useful for personal care products. *BMC Complementary and Alternative Medicine, 14*(1), 1-8.

4. Azevedo, F. R., et al. (2023). Use of essential oils from plants of Araripe National Forest against Aedes aegypti (Diptera: Culicidae). *Brazilian Journal of Biology, 83*(2), e275062.

5. Bezerra, B. M. O., et al. (2020). Suplementação com óleos ricos em ácidos graxos poli-insaturados na dieta de leitões na fase de creche: efeitos no desempenho, na resposta inflamatória, no perfil lipídico e no “status” oxidativo. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 72*(3), 1009–1016.

6. Breda, C. A., et al. (2024). Phytochemical analysis and antifungal activity of extracts from leaves and fruit residues of Brazilian savanna plants aiming its use as safe fungicides. *Natural Products and Bioprospecting, 19*(5), e0302161.

7. Cansian, R. L., et al. (2023). Toxicity and larvicidal activity on Aedes aegypti of citronella essential oil submitted to enzymatic esterification. *Brazilian Journal of Biology, 83*, e244647.

8. Chen, S., et al. (2024). Danggui-Shaoyao-San (DSS) ameliorates the progression of osteoarthritis via suppressing the NF-κB signaling pathway: an in vitro and in vivo study combined with bioinformatics analysis. *Aging, 16*(1), 648–664.

9. Clegg, D. O., et al. (2006). Glucosamine, chondroitin sulfate, and the two in combination for painful knee osteoarthritis. *N Engl J Med, 354*(8), 795-808.

10. Costa, I. R. da, Araújo, F. S. de, & Lima-Verde, L. W. (2004). Aspectos florísticos e autotecológicos de um cerrado disjuntivo no planalto do Araripe, Nordeste do Brasil. *Acta Botânica Brasileira, 18*, 759-770.

11. Coutinho, D. de S., et al. (2020). Pequi (Caryocar brasiliense Cambess)-loaded nanoemulsion, orally delivered, modulates inflammation in LPS-induced acute lung injury in mice. *Pharmaceutics, 12*(11), 1075.

12. De Paula-Ju, W. (2006). Leishmanicidal, antibacterial, and antioxidant activities of Caryocar brasiliense Cambess leaves hydroethanolic extract. *Revista Brasileira de Farmacognosia, 16*(suplemento), 625-630.

13. El-Zahar, K. M., et al. (2022). Antioxidant, antibacterial, and antifungal activities of the ethanolic extract obtained from Berberis vulgaris roots and leaves. *Molecules, 27*(18), 6114.

14. Eden, W. T., et al. (2020). The mosquito repellent activity of the active component of air freshener gel from Java citronella oil (Cymbopogon winterianus). *Journal of Parasitology Research, 2020*(1), 1–5.

15. Figueiredo, P. R. L., et al. (2016). Caryocar coriaceum Wittm. (Pequi) fixed oil presents hypolipemic and anti-inflammatory effects in vivo and in vitro. *J Ethnopharmacol, 191*, 87-94.

16. Fili, R., et al. (2024). Randomized controlled trial of the effectiveness of olive and black seed oil combination on pain intensity and episiotomy wound healing in primiparous women: A study protocol. *Plos One, 19*(5), e0302161.

17. Fonseca, L. D., et al. (2016). Effects of aqueous extracts of Caryocar brasiliense in mice. *Acta Scientiae Veterinariae, 44*(1), 1359.

18. Fracasso, J. A. R., et al. (2023). Anti-inflammatory effect and toxicological profile of pulp residue from the Caryocar brasiliense, a sustainable raw material. *Gels, 9*(3), 234.

19. Geng, H., et al. (2016). Extraction, chemical composition, and antifungal activity of essential oil of bitter almond. *International Journal of Molecular Sciences, 17*(9), 1421.

20. Junior, A. J., et al. (2020). Analgesic and anti-inflammatory effects of Caryocar brasiliense. *Anti-Inflammatory & Anti-Allergy Agents in Medicinal Chemistry, 19*(3), 313–322.

21. Lima, A. F. N., et al. (2022). Efeito larvicida do extrato da folha de pequi (Caryocar brasiliense) sobre o mosquito Aedes aegypti. *Brazilian Journal of Health Review, 5*(4), 14598–14615.

22. Lopes, P. S., et al. (2008). Evaluation of in vitro percutaneous enhancement effect of papain and pequi oil on diclofenac sodium permeation through human skin. *Revista Brasileira de Ciências Farmacêuticas, 44*(2), 1-8.

23. Mendonça, A. M. S., et al. (2022). Ethyl acetate fraction of *Punica granatum* and its galloyl-HHDP-glucose compound, alone or in combination with fluconazole, have antifungal and antivirulence properties against *Candida* spp. *Antibiotics, 11*(2), 265–265.

24. Morais, H. L. M. do N., et al. (2020). Hydroalcoholic extract of Caryocar brasiliense Cambess. leaves affect the development of Aedes aegypti mosquitoes. *Revista da Sociedade Brasileira de Medicina Tropical, 53*(7), 1-7.

25. Mordmuang, A., et al. (2019). Evaluation of a Rhodomyrtus tomentosa ethanolic extract for its therapeutic potential on *Staphylococcus aureus* infections using in vitro and in vivo models of mastitis. *Veterinary Research, 50*(1).

26. Nadja, A., et al. (2021). Assessment of anti-inflammatory and antimicrobial potential of ethanolic extract of *Woodfordia fruticosa* flowers: GC-MS analysis. *Molecules, 26*(23), 7193.

27. Nascimento-Silva, N. R. R. do, & Naves, M. M. V. (2019). Potential of whole pequi (Caryocar spp.) fruit-pulp, almond, oil, and shell-as a medicinal food. *Journal of Medicinal Food, 22*(9), 952-962.

28. Neto, L. J. de L., et al. (2017). Gastroprotective and ulcer healing effects of hydroethanolic extract of leaves of *Caryocar coriaceum*: Mechanisms involved in the gastroprotective activity. *Chemico-Biological Interactions, 26*, 56-62.

29. Oliveira, F. B. B., et al. (2015). Antinociceptive and anti-inflammatory effects of the fixed ethyl acetate extract of the pulp of the fruit of *Caryocar coriaceum* Wittm on zymosan-induced arthritis in rats. *J Ethnopharmacol, 174*(4), 452-463.

30. Passos, X. S., et al. (2002). Atividade antifúngica de *Caryocar brasiliensis* (Caryocaraceae) sobre *Cryptococcus neoformans*. *Revista da Sociedade Brasileira de Medicina Tropical, 35*(6), 623-627.

31. Pinheiro, A. C., et al. (2022). Evaluation of biocompatibility, anti-inflammatory, and antinociceptive activities of pequi oil-based nanoemulsions in in vitro and in vivo models. *Nanomaterials, 12*(23), 4260.

32. Ribeiro, I. C. de O., et al. (2018). Plants of the Cerrado with antimicrobial effects against *Staphylococcus spp.* and *Escherichia coli* from cattle. *BMC Veterinary Research, 14*(1), 32.

33. Roll, M. M., et al. (2018). The pequi pulp oil (*Caryocar brasiliense* Camb.) provides protection against aging-related anemia, inflammation and oxidative stress in Swiss mice, especially in females. *Genetics and Molecular Biology, 41*(4), 858–869.

34. Royo, V. de A., et al. (2022). Physicochemical profile, antioxidant and antimicrobial activities of honeys produced in Minas Gerais (Brazil). *Antibiotics, 11*(10), 1429.

35. Saraiva, M. E. (2015). Plant species as a therapeutic resource in areas of the savanna in the state of Pernambuco, Northeast Brazil. *Journal of Ethnopharmacology, 17*, 141-153.

36. Silva, R. de F., et al. (2022). Enhancement of the functionality of women with knee osteoarthritis by a gel formulation with *Caryocar coriaceum* Wittm (“Pequi”) nanoencapsulated pulp fixed oil. *Biomedicine & Pharmacotherapy, 150*, 112938.

37. Vieira, R. S., et al. (2023). Plantas do Cerrado com atividade larvicida contra *Aedes aegypti*. *Ensaios e Ciência, 27*(2), 222–230.

38. Xiong, W., et al. (2023). The effects of epicuticular wax on anthracnose resistance of *Sorghum bicolor*. *International Journal of Molecular Sciences, 24*(4), 3070–3070.

39. Wang, C., et al. (2023). Antioxidative and anti-inflammatory activities of rosebud extracts of newly crossbred roses. *Nutrients, 15*(10), 2376.

40. Waitzberg, D. L. (2009). *Nutrição oral, enteral e parenteral na prática clínica* (v.2). *Atheneu*.

41. Weinblatt, M. E., et al. (1985). Efficacy of low-dose methotrexate in rheumatoid arthritis. *New England Journal of Medicine, 312*(13), 818–822.

42. Zhakipbekov, K., et al. (2024). Antimicrobial and other pharmacological properties of *Ocimum basilicum*, Lamiaceae. *Molecules, 29*(2), 388–388.