Schinopsis brasiliensis Engler—Phytochemical Properties, Biological Activities, and Ethnomedicinal Use: A Scoping Review

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Abstract: Brazil has the most incredible biodiversity globally and has a vast storehouse of molecules to be discovered. However, there are no pharmacological and phytochemical studies on most native plants. Parts of Schinopsis brasiliensis Engler, a tree from the Anacardiaceae family, are used by several traditional communities to treat injuries and health problems. The objective of this scoping review was to summarize the pharmacological information about S. brasiliensis, from ethnobotanical to phytochemical and biological studies. Data collection concerning the geographical distribution of S. brasiliensis specimens was achieved through the Reflora Virtual Herbarium. The study’s protocol was drafted using the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). The search strategy used the keyword “Schinopsis brasiliensis” in the databases: PUBMED, EMBASE, SCOPUS, Science Direct, Web of Science, SciFinder, and SciELO. Rayyan was used for the selection of eligible studies. In total, 35 studies were included in the paper. The most recurrent therapeutic indications were for general pain, flu and inflammation. The bark was the most studied part of the plant. The most used preparation method was decoction and infusion, followed by syrup. Phytochemical investigations indicate the presence of tannins, flavonoids, phenols, and polyphenols. Most of the substances were found in the plant’s leaf and bark. Important biological activities were reported, such as antimicrobial, antioxidant, and anti-inflammatory. S. brasiliensis is used mainly by communities in the semi-arid region of northeastern Brazil to treat several diseases. Pharmacological and phytochemical studies together provide scientific support for the popular knowledge of the medicinal use of S. brasiliensis. In vitro and in vivo analyses reported antimicrobial, antioxidant, anti-inflammatory, antinociceptive, cytotoxic, photoprotective, preservative, molluscicidal, larvicidal, and pupicidal effects. It is essential to highlight the need for future studies that elucidate the mechanisms of action of these phytocompounds.

Keywords: Schinopsis brasiliensis; phytochemistry; ethnopharmacology; antimicrobial

1. Introduction

Medicinal plants have been used in many cultures for thousands of years, and information on the use of natural resources plays a vital role in discovering new products from plants as therapeutic agents [1]. Brazil is the country with the most extensive biodiversity globally, being a potential storehouse of molecules still not discovered, envisioning their use as a source of therapeutic resources. However, there are still no pharmacological and phytochemical studies on most native plants [2].

Schinopsis brasiliensis Engler is a tree of the Anacardiaceae family, of deciduous behavior, and can reach a height of 20 m (Figure 1) [3]. Its bark is gray, almost black, rough,
and detaches in irregularly square portions, up to 30 mm thick [4]. *S. brasiliensis* is a native tree of the Caatinga, a unique Brazilian Biome located in the semiarid region of Brazilian northeastern, found from latitude 5° S in Ceará and Rio Grande do Norte, to 20° S in Mato Grosso and Minas Gerais [4,5].

Figure 1. *Schinopsis brasiliensis* Engl. Image captured by the authors (Arcoverde/Pernambuco/Brazil—July/2022).

It is popularly known in Brazil as “braúna”, “baraúna”, “braúna-do-sertão”, “braúna-parda”, “quebracho”, “chamacoco” and “chamucoco” [6,7] and in Bolivia as “soto” [3]. *S. brasiliensis* is used for medicinal purposes by several communities, depending on the location studied [8]. According to ethnobotanical surveys, several parts of *S. brasiliensis* are used for the treatment of various injuries and diseases, such as inflammatory disorders [9–11], diarrhea [9,12,13], influenza [9,13–17], cough [12,13,15], and sexual impotence [9,10,13]. The species has already proven biological activities, such as antinociceptive [18,19], anti-inflammatory [18,19], antioxidant [18–22] antimicrobial [23–27], and photoprotective [27,28].

Phytochemical investigations indicate the presence of tannins [10,22,27,29–32], flavonoids [27,30–33], phenols [10,27], saponins [29,33], triterpenes [29,33], quinones [10], alkaloids [29], polyphenols [31], gallic acid [31], condensed tannins, and phenolic acid [33].

Although some research reports the chemical composition and pharmacological activities of *S. brasiliensis* extracts, no review has been published to critically summarize these studies and suggest the use of the plant as a source of molecules of interest for future applications. Thus, the objective of this scoping review was to synthesize pharmacological information about *S. brasiliensis*, from ethnobotanical to phytochemical and biological studies.
2. Material and Methods

2.1. Geographical Distribution of S. brasiliensis

The collection of data concerning the geographical distribution of identified *S. brasiliensis* specimens was achieved through the Reflora Virtual Herbarium (Reflora Program—CNPq-https://reflora.jbrj.gov.br/reflora/herbarioVirtual, accessed on 28 May 2021). The previous authorization was conceded, and latitude and longitude data of each collected specimen were retrieved. Then, we plotted a map using RStudio 1.4 (through ‘geobr’ and ‘ggspatial’ packages) with the retrieved geographical data.

2.2. Protocol and Registration

The study’s protocol was drafted using the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [34]. The final protocol was registered with the Open Science Framework on 4 June 2021 (https://doi.org/10.17605/osf.io/drjns, accessed on 4 June 2021).

2.3. Eligibility Criteria

Studies were included if: (i) published until 25 May 2021; (ii) a peer-reviewed publication; (iii) written in English, Portuguese, or Spanish; (iv) that had described the use of *Schinopsis brasiliensis*. Non-original articles were excluded, such as monographs, dissertations, theses, bibliographic reviews, letters, comments, editorials, or book chapters and studies that did not describe an antimicrobial, ethnobotanical, or a phytochemical approach to *S. brasiliensis*.

2.4. Search Strategy and Information Sources

The search strategy used the keyword “*Schinopsis brasiliensis*” in the following bibliographic databases: PUBMED, EMBASE, SCOPUS, Science Direct, Web of Science, SciFinder, and SciELO. The final search results of each database were exported and downloaded in CIW or RIS format. The files were imported into the online platform of Rayyan QCRI (RRID:SCR_017584-PMID: 27919275-https://www.rayyan.ai, accessed on 4 June 2021), and duplicates were removed.

2.5. Selection of Sources of Evidence

Rayyan was used to select eligible studies [35]. Based on the eligibility criteria, two reviewers (MKGD and WMSB) independently evaluated the same titles, abstracts, and full text of all publications identified by the searches. The disagreements on study selection and data extraction were resolved by consensus and discussion with a third reviewer (PHSS), when needed. The intra- and interobserver Kappa coefficients were performed using 70% of previously identified studies. The selection of sources was carried out until 25 May 2021. However, a new search was performed on 5 July 2022, to update the selected studies.

2.6. Data Items and Synthesis of Results

The data of selected studies according to the study approach (ethnobotanical, antimicrobial, phytochemical) were extracted and summarized as shown in the Tables. Study localization, plant part, extraction product, the method for extraction, compound class, identified compound, biological activity, and therapeutic indication were collected for each study.

3. Results

3.1. Geographical Distribution of S. brasiliensis

Based on the Reflora Virtual Herbarium data, we observed that the Caatinga Biome (northeastern Brazil) contained the majority of identified *Schinopsis brasiliensis* Engl specimens (Figure 2). Five specimens were identified in other regions, one in northeastern Pará and four in northeastern Goiás. There is a large concentration of specimens identified between 7° S/15° S and 36° W/43° W.
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**Figure 2.** Geographical distribution of identified *Schinopsis brasiliensis* Engl specimens from the Reflora Virtual Herbarium collection found in Brazil. (Map plotted using RStudio 1.4 with ‘geobr’ and ‘ggspatial’ packages).

### 3.2. Summary of the Articles

A total of 388 titles were retrieved using the search strategy. After the removal of duplicates, 100 unique studies were independently evaluated by reviewers using eligibility criteria (Figure 3). The intra-observer Kappa coefficient was 0.96 (C.I. 0.76–1.00) and the inter-observer was 0.92 (C.I. 0.62–1.00). After full reading and updating references, 36 published studies were included in this scoping review.

### 3.3. Ethnobotanical Studies

Ethnobotanical studies have shown different ways to use *S. brasiliensis* by local communities, besides its uses for treating various symptoms (Table 1).

**Table 1.** List of therapeutic indications of *Schinopsis brasiliensis* Engler according to the results of the ethnobotanical surveys.

| Therapeutic Indication            | Location | Used Part | Preparation | Reference                   |
|----------------------------------|----------|-----------|-------------|-----------------------------|
| Antitussive, diarrhea, and dysentery | Cabaceiras/PB, São João do Cariri/PB, Serra Branca/PB, Monteiro/PB | Bark | Decoction, syrup | Agra et al. [12] |
| Cold and flu | Alagoinha/PE | Bark | Infusion, Syrup | Albuquerque [14] |
| Antitussive and flu | Alagoinha/PE | Bark | Decoction, Syrup | Albuquerque and Andrade [15] |
Table 1. Cont.

| Therapeutic Indication                        | Location          | Used Part              | Preparation           | Reference                |
|-----------------------------------------------|-------------------|------------------------|------------------------|--------------------------|
| Fracture, Inflammation, Sexual Impotence, Sore Throat Cold, Flu, and Diarrhea | Unreported        | Bark, Leaf, Fruit, Seed, Resin | Unreported             | Albuquerque et al. [9]   |
| Antihisteric, nervosthenic, tonic, toothache, earache, verminosis | Campina Grande/PB | Resin, Bark            | Tincture, Decoction, Infusion | Albuquerque et al. [36] |
| Inflammation and Sexual Impotence             | Piranhas/AL, Delmiro Gouveia/AL | Bark               | Unreported             | Almeida et al. [10]      |
| Menstrual Cramps, Inflammation, Infection     | Altinho/PE        | N/E                    | Unreported             | Ferreira-Júnior et al. [11] |
| Prostate, anticoagulant, flu, and bones       | Jeremoabo/BA      | Bark                   | Maceration, Tea, Syrup | Gomes and Bandeira [16]  |
| Back pain, nerve pain, flu                    | Monteiro/PB       | Flower                 | Decoction              | Pereira-Júnior et al. [17] |
| Stomach pain, liver pain                      | Assaré/CE         | Leaf                   | Decoction              | Ribeiro et al. [37]      |
| Cough, flu, diarrhea, fractures, sexual impotence | Unreported        | Bark                   | Unreported             | Silva et al. [13]        |

PB: Paraíba; PE: Pernambuco; AL: Alagoas; BA: Bahia; CE: Ceará.

Figure 3. Flow chart of the articles selection process according to PRISMA-ScR.
All ethnobotanical studies presented are Brazilian (n = 11,100%), from the Northeast region (Figure 4). General pain (tooth, ear, throat, stomach, liver, back, nerves, and menstrual cramps) was the most recurrent therapeutic indication (n = 8; 72.72%), followed by influenza (n = 6; 54.54%), and inflammation (n = 3; 27.27%). The barks were the most studied part of the plant (n = 7, 63.63%). The most used preparation method was the tea-decoction or infusion (n = 7, 63.63%). Thus, we observed the way that S. brasiliensis is used as a medicinal drug and the preparation mode.

Figure 4. Regions of the Ethnobotanical Surveys (black) conducted in Brazil, with emphasis on the Caatinga Biome (gray).

3.4. Phytochemistry Studies

Eleven studies showed the phytochemical classes of S. brasiliensis, without identifying the compounds (Table 2). We noted that the plant is a phenolic compound source. Tannins are identified almost always (n = 10; 90.9%), although flavonoids (n = 7; 63.63%), phenols and polyphenols (n = 3; 27.27%), triterpenes and saponins (n = 2; 18.18%) are also observed in the papers. A lot of studies had isolated many phytocompounds from S. brasiliensis, according to the plant’s part (Table 3).

Table 2. Phytochemical compounds found in Schinopsis brasiliensis.

| Used Part | Extract  | Compound | Amount                  | Reference                  |
|-----------|----------|----------|-------------------------|----------------------------|
| Unreported| Ethanolic| Alkaloids | -                       | Almeida et al. [29]        |
| Bark      | Ethanolic| Flavonoids| 132.4 ± 1.76 mg/g (RE)  | Lima-Saraiva et al. [27]   |
| Bark      | Ethanolic| Flavonoids| 6.94 mg/g               | Sette-de-Souza et al. [24] |
| Bark      | Hydroalcoholic| Flavonoids| 1.44%                   | Fernandes et al. [31]      |
| Bark      | Hydroalcoholic| Flavonoids| 10.16 ± 0.54 mg/g       | Sette-de-Souza et al. [23] |
| Bark      | Methanolic| Flavonoids| 2.63%                   | Araujo et al. [30]         |
| Bark      | Methanolic| Flavonoids| -                       | Saraiva et al. [33]        |
| Flowers   | Methanolic| Flavonoids| -                       | Saraiva et al. [33]        |
Table 2. Cont.

| Used Part  | Extract | Compound     | Amount               | Reference                          |
|------------|---------|--------------|----------------------|------------------------------------|
| Fruit      | Methanolic | Flavonoids  | -                    | Saraiva et al. [33]                |
| Leaves     | Methanolic | Flavonoids  | -                    | Saraiva et al. [33]                |
| Root       | Methanolic | Flavonoids  | -                    | Saraiva et al. [33]                |
| Seeds      | Methanolic | Flavonoids  | -                    | Saraiva et al. [33]                |
| Bark       | Unreported | Flavonoids  | 2.55%                | Siqueira et al. [32]               |
| Bark       | Hydroalcoholic | Gallic acid | -                    | Fernandes et al. [31]              |
| Heartwood  | Butanol  | Phenol       | 501.94 ± 10.49 mg/g (GAE) | Moreira et al. [19]                |
| Root Bark  | Butanol  | Phenol       | 505.25 ± 11.65 mg/g (GAE) | Moreira et al. [19]                |
| Heartwood  | Chloroform | Phenol     | 474.38 ± 7.07 mg/g (GAE) | Moreira et al. [19]                |
| Root Bark  | Chloroform | Phenol      | 525.31 ± 2.67 mg/g (GAE) | Moreira et al. [19]                |
| Bark       | Ethanolic | Phenol       | -                    | Almeida et al. [10]                |
| Bark       | Ethanolic | Phenol       | 493.88 ± 13.23 mg/g (TAE) | Almeida-Andrade et al. [28]        |
| Bark       | Ethanolic | Phenol       | 624.6 ± 0.42 mg/g (GAE) | Lima-Saraiva et al. [27]           |
| Heartwood  | Ethyl Acetate | Phenol   | 816.37 ± 15.40 mg/g (GAE) | Moreira et al. [19]                |
| Root Bark  | Ethyl Acetate | Phenol   | 648.26 ± 6.01 mg/g (GAE) | Moreira et al. [19]                |
| Heartwood  | Hexane   | Phenol       | 19.14 ± 2.67 mg/g (GAE) | Moreira et al. [19]                |
| Root Bark  | Hexane   | Phenol       | 76.61 ± 6.7 mg/g (GAE) | Moreira et al. [19]                |
| Bark       | Methanolic | Phenolic acid| -                    | Saraiva et al. [33]                |
| Flowers    | Methanolic | Phenolic acid| -                    | Saraiva et al. [33]                |
| Fruit      | Methanolic | Phenolic acid| -                    | Saraiva et al. [33]                |
| Leaves     | Methanolic | Phenolic acid| -                    | Saraiva et al. [33]                |
| Root       | Methanolic | Phenolic acid| -                    | Saraiva et al. [33]                |
| Seeds      | Methanolic | Phenolic acid| -                    | Saraiva et al. [33]                |
| Bark       | Ethanolic | Polyphenols  | 598.55 mg/g          | Sette-de-Souza et al. [24]         |
| Bark       | Hydroalcoholic | Polyphenols | 15.08%               | Fernandes et al. [31]              |
| Bark       | Hydroalcoholic | Polyphenols | 586.13 ± 9.38 mg/g    | Sette-de-Souza et al. [23]         |
| Bark       | Ethanolic | Quinones     | -                    | Almeida et al. [10]                |
| Unreported | Ethanolic | Saponins     | -                    | Almeida et al. [29]                |
| Bark       | Methanolic | Saponins     | -                    | Saraiva et al. [33]                |
| Flowers    | Methanolic | Saponins     | -                    | Saraiva et al. [33]                |
| Fruit      | Methanolic | Saponins     | -                    | Saraiva et al. [33]                |
| Leaves     | Methanolic | Saponins     | -                    | Saraiva et al. [33]                |
| Root       | Methanolic | Saponins     | -                    | Saraiva et al. [33]                |
| Seeds      | Methanolic | Saponins     | -                    | Saraiva et al. [33]                |
| Bark       | Ethanolic | Tannins      | 367.12 ± 21.35 mg/g (TAE) | Almeida-Andrade et al. [28]        |
| Bark       | Ethanolic | Tannins      | 255.8 ± 2.06 mg/g (TAE) | Lima-Saraiva et al. [27]           |
| Bark       | Ethanolic | Tannins      | 15.83 mg/g           | Sette-de-Souza et al. [24]         |
| Unreported | Ethanolic | Tannins      | -                    | Almeida et al. [29]                |
| Bark       | Hydroalcoholic | Tannins  | 27.12 ± 0.61 mg/g    | Sette-de-Souza et al. [23]         |
| Bark       | Methanolic | Tannins      | 50.24%               | Araújo et al. [30]                 |
| Bark       | Methanolic | Tannins      | -                    | Saraiva et al. [33]                |
| Flowers    | Methanolic | Tannins      | -                    | Saraiva et al. [33]                |
| Fruit      | Methanolic | Tannins      | -                    | Saraiva et al. [33]                |
| Leaves     | Methanolic | Tannins      | -                    | Saraiva et al. [33]                |
| Root       | Methanolic | Tannins      | -                    | Saraiva et al. [33]                |
| Seeds      | Methanolic | Tannins      | -                    | Saraiva et al. [33]                |
| Bark       | Unreported | Tannins      | 5.53%                | Siqueira et al. [32]               |
| Leaves and Bark | Unreported | Tannins  | 78.9 ± 12.2 mg/g     | Oliveira et al. [38]               |
| Bark       | Ethanolic | Triterpene   | -                    | Almeida et al. [10]                |
| Bark       | Methanolic | Triterpene   | -                    | Saraiva et al. [33]                |
| Flowers    | Methanolic | Triterpene   | -                    | Saraiva et al. [33]                |
| Fruit      | Methanolic | Triterpene   | -                    | Saraiva et al. [33]                |
| Leaves     | Methanolic | Triterpene   | -                    | Saraiva et al. [33]                |
| Root       | Methanolic | Triterpene   | -                    | Saraiva et al. [33]                |
| Seeds      | Methanolic | Triterpene   | -                    | Saraiva et al. [33]                |

TAE: Tannic acid equivalent; GAE: Gallic acid equivalents; RE: Rutin equivalent.
Table 3. Isolated compounds from *Schinopsis brasiliensis*.

| Isolated Compound | Class | Plant Part | Reference |
|-------------------|-------|------------|-----------|
| Sylvestrene       | Alkene| Leaves     | Donati et al. [20] |
| Quercetin- O- (O-galloyl) –hexoside | Benzoate | Leaves | Reis-Luz et al. [39] |
| Methyl 6-eicosanyl-2-hydroxy-4-methoxybenzoate | Benzoate | Bark | Cardoso et al. [40] |
| Urundeuvin A       | Benzopyran | Branch | Reis-Luz et al. [39] |
| Chlorogenic acid   | Carboxylic acid | Bark | Reis-Luz et al. [39] |
| Citric Acid        | Carboxylic acid | Bark | Reis-Luz et al. [39] |
| Digalloyl Quinic Acid | Carboxylic acid | Bark | Reis-Luz et al. [39] |
| Quinic acid        | Carboxylic acid | Bark | Reis-Luz et al. [39] |
| Chlorogenic acid   | Carboxylic acid | Branch | Reis-Luz et al. [39] |
| Quinic acid        | Carboxylic acid | Branch | Reis-Luz et al. [39] |
| Quinic acid        | Carboxylic acid | Leaves | Reis-Luz et al. [39] |
| Cajobin            | Chalcone | Root bark | Moreira et al. [19] |
| Luxenchalcone      | Chalcone | Root bark | Moreira et al. [19] |
| 5α, 8x-epidioxyergosta-6,22-dien-3-b-ol | Flavonoid | Bark | Cardoso et al. [41] |
| 4,2′,4′-tri-hydroxichalcona-(3→O)2,4″′-dihydroxiccalcona | Flavonoid | Bark | Lima-Saraiva et al. [27] |
| Apigenin           | Flavonoid | Bark | Lima-Saraiva et al. [27] |
| Epicatechin        | Flavonoid | Bark | Lima-Saraiva et al. [27] |
| Ethyl-O-β-D-(6′-galloyl)-glucopyranoside | Flavonoid | Branch | Reis-Luz et al. [39] |
| C20H28O23         | Flavonoid | Leaves | Cardoso et al. [41] |
| C30H20O9          | Flavonoid | Leaves | Reis-Luz et al. [39] |
| C31H20O14         | Flavonoid | Leaves | Reis-Luz et al. [39] |
| C46H36O21         | Flavonoid | Leaves | Reis-Luz et al. [39] |
| C28H34O17         | Flavonoid | Leaves | Reis-Luz et al. [39] |
| C45H35O14         | Flavonoid | Branch | Reis-Luz et al. [39] |
| C14H4O            | Flavonoid | Leaves | Reis-Luz et al. [39] |
| C18H26O14         | Flavonoid | Leaves | Reis-Luz et al. [39] |
| C26H36O11         | Flavonoid | Leaves | Reis-Luz et al. [39] |
| C28H26O17         | Flavonoid | Leaves | Reis-Luz et al. [39] |
| C30H22O9          | Flavonoid | Root bark | Moreira et al. [19] |
| C46H36O12         | Flavonoid | Root bark | Moreira et al. [19] |
| Methyl Gallate    | Phenol Compound | Root bark | Moreira et al. [19] |
| Cynamic Derivate   | Phenolic acid | Bark | Saraiva et al. [33] |
| Cynamic Derivate   | Phenolic acid | Flowers | Saraiva et al. [33] |
Eight studies described 64 isolated chemical compounds from *S. brasiliensis*. Polyphenols were the most prevalent chemical group identified ($n = 15; 23.43\%$), followed by terpenes ($n = 13; 20.31\%$). Most of the compounds were found in the leaves ($n = 31; 48.43\%$).

### 3.5. Antimicrobial Activity

Fourteen studies presented results on the antibacterial activity of *S. brasiliensis* extracts against 17 bacteria, eight Gram-negative and nine Gram-positive. Table 4 summarizes the studies that reported the antibacterial activity of *S. brasiliensis* extracts. Notably, the leaf extract of *S. brasiliensis* showed antifungal activity against *C. albicans*, *C. tropicalis*, and *C. krusei* [6,22]. In addition, Formiga-Filho et al. [26] noted that the association of *S. brasiliensis* bark extract with low-power laser increases its activity against *E. coli*, *S. aureus*, *P. aeruginosa*, and *E. faecalis*. 

| Isolated Compound | Class | Plant Part | Reference |
|-------------------|-------|------------|-----------|
| Cynamic Derivate Phenolic acid Fruit | Saraiva et al. [33] |
| Cynamic Derivate Phenolic acid Leaves | Saraiva et al. [33] |
| Cynamic Derivate Phenolic acid Root | Saraiva et al. [33] |
| Cynamic Derivate Phenolic acid Seeds | Saraiva et al. [33] |
| Estragole (4-allylanisole) Phenols Leaves | Donati et al. [20] |
| Daucosterol Phytosterol Heartwood | Moreira et al. [19] |
| 2-hydroxy-4-methoxyphenol-1-O-β-D-(6′-O-galloyl)-glucopyranoside | Polyphenol Bark | Reis-Luz et al. [39] |
| Galloyl quinic acid Polyphenol Bark | Reis-Luz et al. [39] |
| Proanthocyanidin Polyphenol Bark | Saraiva et al. [33] |
| 2-hydroxy-4-methoxyphenol-1-O-β-D-(6′-O-galloyl)-glucopyranoside Polyphenol Branch | Reis-Luz et al. [39] |
| Di-O-galloyl-2,3-(S)-hexahydroxydiphenoy1-scyllquercitol Polyphenol Branch | Reis-Luz et al. [39] |
| Galloyl quinic acid Polyphenol Branch | Reis-Luz et al. [39] |
| Hexagalloyl-hexoside Polyphenol Branch | Reis-Luz et al. [39] |
| Proanthocyanidin Polyphenol Fruit | Saraiva et al. [33] |
| Digallic acid Polyphenol Leaves | Reis-Luz et al. [39] |
| Ethyl 2,4-dihydroxy-3-(3,4,5-trihydroxybenzoyl)oxybezozate Polyphenol Leaves | Reis-Luz et al. [39] |
| Hexagalloyl-hexoside Polyphenol Leaves | Reis-Luz et al. [39] |
| Tetra-O-galloyl-glucose Polyphenol Leaves | Reis-Luz et al. [39] |
| Proanthocyanidin Polyphenol Root | Saraiva et al. [33] |
| Ellagic Acid Polyphenol Root bark | Moreira et al. [19] |
| Corilagin Tannin Branch | Reis-Luz et al. [39] |
| Aromadendrene Terpene Leaves | Donati et al. [20] |
| Eucalyptol (cineol) Terpene Leaves | Donati et al. [20] |
| Globulol Terpene Leaves | Donati et al. [20] |
| Guaiol Terpene Leaves | Donati et al. [20] |
| Ledene Terpene Leaves | Donati et al. [20] |
| Linalol Terpene Leaves | Donati et al. [20] |
| Myrcene Terpene Leaves | Donati et al. [20] |
| Terpinen-4-ol Terpene Leaves | Donati et al. [20] |
| α-humulene (α-caryophyllene) Terpene Leaves | Donati et al. [20] |
| α-pinene Terpene Leaves | Donati et al. [20] |
| β-caryophyllene Terpene Leaves | Donati et al. [20] |
| β-element Terpene Leaves | Donati et al. [20] |
### Table 4. Antimicrobial activity *Schinopsis brasiliensis*.

| Plant Part   | Extract     | Microorganism       | MIC          | Control                     | Reference                           |
|--------------|-------------|---------------------|--------------|-----------------------------|-------------------------------------|
| Barks        | Hydroalcoholic | *E. faecalis*       | 0.25 mg/mL   | Chlorhexidine               | Sette-de-Souza et al. [23]          |
|              |             | *S. mutans*         | 0.5 mg/mL    |                             |                                     |
|              |             | *S. oralis*         | 0.5 mg/mL    |                             |                                     |
|              |             | *S. mitis*          | 0.5 mg/mL    |                             |                                     |
|              |             | *S. salivarius*     | 0.25 mg/mL   |                             |                                     |
| Barks        | Ethanolic   | *S. choleraesuis*   | 37.32 mg/mL  | Tetracycline, Nystatin solution | Farias et al. [25]                 |
|              | Hydroalcoholic | *S. aureus*         | 50 mg/mL     | Malachite Green dye         | Formiga-Filho et al. [26]          |
|              |             | *Escherichia*       | 500 mg/mL    |                             |                                     |
|              |             | *P. aeruginosa*     | 50 mg/mL     |                             |                                     |
|              |             | *E. faecalis*       | 200 mg/mL    |                             |                                     |
| Leaves       | Hydroalcoholic | *S. aureus*         | 50 mg/mL     | Malachite Green dye         | Formiga-Filho et al. [26]          |
|              |             | *E. coli*           | 200 mg/mL    |                             |                                     |
|              |             | *P. aeruginosa*     | 50 mg/mL     |                             |                                     |
|              |             | *E. faecalis*       | 100 mg/mL    |                             |                                     |
|              |             | *B. cereus*         | 12.5 mg/mL   |                             |                                     |
|              |             | *E. coli*           | 12.5 mg/mL   |                             |                                     |
|              |             | *E. faecalis*       | 12.5 mg/mL   |                             |                                     |
|              |             | *K. pneumoniae*     | 12.5 mg/mL   | Gentamicin                  | Lima-Saraiva et al. [27]           |
|              |             | *P. aeruginosa*     | 12.5 mg/mL   |                             |                                     |
|              |             | *S. marcescens*     | 6.25 mg/mL   |                             |                                     |
|              |             | *S. flexneri*       | 3.12 mg/mL   |                             |                                     |
|              |             | *S. enterica*       | 0.39 mg/mL   |                             |                                     |
|              |             | *S. aureus*         | 3.12 mg/mL   |                             |                                     |
|              |             | *S. haemolyticus*   | 0.17 mg/mL   |                             |                                     |
|              |             | *S. aureus*         | 0.17 mg/mL   |                             |                                     |
|              |             | *E. coli*           | 0.17 mg/mL   |                             |                                     |
|              |             | *S. aureus*         | 0.125 mg/mL  |                             |                                     |
|              |             | *S. saprophyticus*  | 500 µg/mL    |                             |                                     |
|              |             | *S. epidermidis*    | 500 µg/mL    |                             |                                     |
|              |             | *P. aeruginosa*     | 31.25 µg/mL  |                             |                                     |
| Leaves       | Methanolic   | *E. coli*           | 0.23 µg/mL   | Ceftriaxone                 | Oliveira et al. [43]               |
|              | Ethyl Acetate | *K. pneumoniae*     | 10 µg/mL     |                             |                                     |
| Leaves,     | Methanolic   | *S. aureus*         | 0.125 mg/mL  | Tetraciclin                 | Saraiva et al. [33]               |
| Flowers, Root, | Ethyl Acetate | *E. coli*           | 250 µg/mL    |                             |                                     |
| Bark, Fruits|              | *E. faecalis*       | 2 µg/mL      |                             |                                     |
|              |              | *S. aureus*         | 125 µg/mL    |                             |                                     |
|              |              | *S. saprophyticus*  | 500 µg/mL    |                             |                                     |
|              |              | *S. epidermidis*    | 500 µg/mL    |                             |                                     |
|              |              | *P. aeruginosa*     | 31.25 µg/mL  |                             |                                     |
Table 4. Cont.

| Plant Part | Extract | Microorganism | MIC | Control | Reference |
|------------|---------|---------------|-----|---------|-----------|
| Leaves     | Ethyl Acetate | *S. aureus* | 100 µg/mL | Tetracycline, Oxacilin | Saraiva et al. [6] |
|            |         | *E. coli*     | >100 µg/mL |         |           |
|            |         | *K. pneumoniae* | >100 µg/mL |         |           |
|            |         | *E. faecalis* | >100 µg/mL |         |           |
|            |         | *Salmonella* spp. | >100 µg/mL |         |           |
| Leaves     | Methanolic | *S. aureus* | 25 µg/mL |         | Saraiva et al. [6] |
|            |         | *E. coli* | 50 µg/mL |         |           |
|            |         | *K. pneumoniae* | 100 µg/mL |         |           |
|            |         | *E. faecalis* | >100 µg/mL |         |           |
|            |         | *Salmonella* spp. | >100 µg/mL |         |           |
|            |         | *C. albicans* | 200 µg/mL | Ketoconazole |           |
|            |         | *C. krusei* | 200 µg/mL |         |           |
|            |         | *C. tropicalis* | 200 µg/mL |         |           |
| Barks      | Hydroalcoholic | *P. aeruginosa* | 0.004 µL/µL | Chlorhexidine | Silva et al. [1] |
|            |         | *E. faecalis* | 1 µL/µL |         |           |
|            |         | *S. aureus* | 0.063 µL/µL |         |           |
|            |         | *S. oralis* | 0.5 µL/µL |         |           |
| Leaves     | Ethanolic | *S. aureus* | 1.04 mg/mL | Erythromycin | Silva et al. [44] |
| Barks      | Ethanolic | *S. aureus* | 1.04 mg/mL | Erythromycin | Silva et al. [44] |
| Root bark  | Hexane   | *S. aureus* | >1000 µg/mL | - | Moreira et al. [19] |
| Root bark  | Chloroform | *S. aureus* | 31.25 µg/mL | - | Moreira et al. [19] |
| Root bark  | Ethyl Acetate | *S. aureus* | 62.50 µg/mL | - | Moreira et al. [19] |
| Root bark  | Butanol  | *S. aureus* | 125 µg/mL | - | Moreira et al. [19] |
| Heartwood  | Hexane   | *S. aureus* | >1000 µg/mL | - | Moreira et al. [19] |
| Heartwood  | Chloroform | *S. aureus* | 250 µg/mL | - | Moreira et al. [19] |
| Heartwood  | Ethyl Acetate | *S. aureus* | 62.50 µg/mL | - | Moreira et al. [19] |
| Heartwood  | Butanol  | *S. aureus* | 250 µg/mL | - | Moreira et al. [19] |

In these studies, the bark was the most used plant structure (n = 7; 50%), followed by the leaves (n = 6; 44.8%). The ethanolic extract was used in 44.8% of the studies (n = 6). The most cited bacterium in the studies was *Staphylococcus* spp. (n = 9; 63.5%). The range of Minimum Inhibitory Concentration (MIC) varied as to concentrations, being 1 µL/µL for *E. faecalis* [1], 0.23 µg/mL for *Escherichia coli* [43], 0.004 µL/µL for *P. aeruginosa* [1] and 10 µg/mL for *K. pneumoniae* [43].

Besides the antimicrobial activity of the extracts, two studies evaluated the antibacterial effect of controlled release systems containing *S. brasiliensis*. The production of chitosan microparticles-loaded *S. brasiliensis* bark extract would be an alternative for the use of the extract in dentistry due to the improved organoleptic properties [23]. The MIC values of these microparticles were lower than that observed for the hydroalcoholic extract (0.25 mg/mL and 0.50 mg/mL, respectively). Furthermore, the microparticles inhibited biofilm development and growth of *E. faecalis* in 24 h. Through cytotoxicity analyses performed by Sette-de-Souza et al. [23], it was proven that microparticles are safe for use in the treatment of *Enterococci* infections and in dentistry due to their potential to inhibit biofilm development.
Oliveira et al. [43] showed that *S. brasiliensis* nanoparticles associated with ceftriaxone showed inhibitory activity against *E. coli*, including against ceftriaxone-resistant strains. These results express the capacity and importance of the use of controlled-release systems in the delivery of atypical pharmaceutical ingredients, demonstrating to be an excellent possibility for the treatment of infections caused by multidrug-resistant bacteria.

### 3.6. Antioxidant Activity

The antioxidant activity of *S. brasiliensis* extracts was evaluated in six studies (Table 5), through four tests: Oxygen Radical Absorbance Capacity-ORAC [20], 2,2-Diphenyl-1-Picryl-Hydrazyl-DPPH [19,20,22,27,28], β-Carotene [19,27] and Trolox Equivalent Antioxidant Capacity-TEAC [21]. Twenty-three results were obtained from the six studies. The DPPH (*n* = 11; 47.82%) and β-carotene (*n* = 9; 39.13%) methods were most used.

| Plant Part | Extract | Method       | Main Result       | Reference               |
|------------|---------|--------------|-------------------|-------------------------|
| Bark       | Ethanolic | DPPH         | IC₅₀: 1.46 ± 0.07 µg/mL | Lima-Saraiva et al. [27] |
| Bark       | Ethanolic | β-carotene   | 60.81%             | Lima-Saraiva et al. [27] |
| Bark       | Ethanolic | TEAC         | 3.04 µg/mL         | Santos et al. [21]      |
| Bark       | Ethanolic | DPPH         | IC₅₀: 19.69 ± 0.77 µg/mL | Almeida-Andrade et al. [28] |
| Leaf       | Essential Oil | ORAC | 1918, 3 ± 246 µmol/g | Donati et al. [20]     |
| Leaf       | Essential Oil | DPPH | IC₅₀: 17.63 mg/mL (9.19–33.82) | Donati et al. [20]  |
| Root bark  | Hexane   | DPPH         | >1000 µg/mL        | Moreira et al. [19]    |
| Root bark  | Chloroform | DPPH | 101.53 µg/mL     | Moreira et al. [19]    |
| Root bark  | Ethyl Acetate | DPPH | 38.37 µg/mL     | Moreira et al. [19]    |
| Root bark  | Butanol  | DPPH         | 53.46 µg/mL        | Moreira et al. [19]    |
| Root bark  | Hexane   | β-carotene   | 39.64 µg/mL        | Moreira et al. [19]    |
| Root bark  | Chloroform | β-carotene | 115.74 µg/mL   | Moreira et al. [19]    |
| Root bark  | Ethyl Acetate | β-carotene | 127.16 µg/mL   | Moreira et al. [19]    |
| Heartwood  | Hexane   | β-carotene   | 29.65 µg/mL        | Moreira et al. [19]    |
| Heartwood  | Chloroform | DPPH | >1000 µg/mL     | Moreira et al. [19]    |
| Heartwood  | Ethyl Acetate | β-carotene | 31.42 µg/mL   | Moreira et al. [19]    |
| Heartwood  | Butanol  | β-carotene   | 109.72 µg/mL       | Moreira et al. [19]    |

DPPH: 2,2-Diphenyl-1-Picryl-Hydrazyl; TEAC: Trolox Equivalent Antioxidant Capacity; ORAC: Oxygen Radical Absorbance Capacity; IC₅₀: Inhibitory Concentration; EC₅₀: Efficient Concentration.

### 3.7. Cytotoxic Activity

The cytotoxic activity was evaluated in different experimental models (Table 6). The bark was the most used part of *S. brasiliensis* (*n* = 13; 52%). In vivo studies (*n* = 10; 40%) used model *Artemia salina* (*n* = 9; 90%) [1,22,45–47] and *Ceriodaphnia dubia* (*n* = 1; 10%) [47] were tested and the LC₅₀ ranged from 1.91 mg/mL to 962.97 µg/mL. In vitro studies (*n* = 15; 60%) evaluated cytotoxicity against fibroblasts cell lines (*n* = 3; 20%) [39,47] or cancer lines (*n* = 12; 80%) [39]. In this way, *S. brasiliensis* should be a promising anticancer agent.

| Study Design | Plant Part | Extract | Experimental Models | LC₅₀/IC₅₀ | Reference               |
|--------------|------------|---------|---------------------|-----------|-------------------------|
| In vivo      | Bark       | Ethanolic | *Artemia salina*     | LC₅₀ > 100 µg/mL | Santos et al. [46]     |
| In vivo      | Bark       | Methanolic | *Artemia salina*     | LC₅₀ > 100 µg/mL | Santos et al. [46]     |
| In vivo      | Bark       | Chloroform | *Artemia salina*     | LC₅₀ = 313 µg/mL | Santos et al. [46]     |
| In vivo      | Bark       | Hexane   | *Artemia salina*     | LC₅₀ = 582 µg/mL | Santos et al. [46]     |
**Table 6. Cont.**

| Study Design | Plant Part | Extract | Experimental Models | LC50/IC50 | Reference |
|--------------|------------|---------|---------------------|-----------|-----------|
| In vivo      | Bark       | Ethyl acetate | *Artemia salina*   | LC50: 557 µg/mL | Santos et al. [46] |
| In vivo      | Bark       | Hydroalcoholic | *Artemia salina*   | LC50: 428 µg/mL | Silva et al. [1]  |
| In vivo      | Leaf       | Methanolic | *Artemia salina*   | LC50: 705.54 ± 60.46 µg/mL | Saraiva et al. [22] |
| In vivo      | Leaf       | Ethanolic | *Artemia salina*   | LC50: 512 µg/mL | Silva et al. [44] |
| In vitro     | Seed       | SPP      | Ceriodaphnia dubia | LC50: 1.91 mg/mL | Barbosa et al. [47] |
| In vitro     | Seed       | Ethanolic | *Artemia sp*       | LC50: 962.97 µg/mL | Souza et al. [45] |
| In vitro     | Seed       | SPF      | Fibroblasts 3T3     | LC50: 6.14 mg/mL | Barbosa et al. [47] |
| In vitro     | Leaf       | Hydroalcoholic | *Glioblastoma SF-295* | IC50: 78.37 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Leaf       | Hydroalcoholic | Prostate PC3       | IC50: 71.54 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Leaf       | Hydroalcoholic | Leukemia HL60     | IC50: 52.58 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Leaf       | Hydroalcoholic | Colorectal RAJI  | IC50: 55.90 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Leaf       | Hydroalcoholic | Colorectal HCT-116 | IC50: 61.73 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Leaf       | Hydroalcoholic | Colorectal SW-620 | IC50: 65.46 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Leaf       | Hydroalcoholic | Fibroblast L929    | IC50: 49.53 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Bark       | Hydroalcoholic | *Glioblastoma SF-295* | IC50: 100 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Bark       | Hydroalcoholic | Prostate PC3       | IC50: 100 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Bark       | Hydroalcoholic | Leukemia HL60     | IC50: 58.75 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Bark       | Hydroalcoholic | Colorectal RAJI  | IC50: 100 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Bark       | Hydroalcoholic | Colorectal HCT-116 | IC50: 93.64 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Bark       | Hydroalcoholic | Colorectal SW-620 | IC50: 25.68 µg/mL | Reis-Luz et al. [39] |
| In vitro     | Bark       | Hydroalcoholic | Fibroblast L929    | IC50: 82.00 µg/mL | Reis-Luz et al. [39] |

SPF = Sodium phosphate buffer.

3.8. Other Biological Activities

Other biological activities of *S. brasiliensis* extracts have also been reported, such as photoprotective against Ultraviolet B radiation [27,28], sunscreen preservative [48], molluscidal [46], larvicidal [45–47], pupicidal [45,47], ovicidal [45,47], anti-inflammatory [18,19], nociceptive [18,19], antihemolytic [23,24,27] and enzyme inhibiting [47] (Table 7).

**Table 7. Other biological activity from Schinus brasiliensis.**

| Biological Activity | Plant Part | Extract | Method (Study Design) | Main Results | IC50 | Reference |
|---------------------|------------|---------|-----------------------|--------------|------|-----------|
| Photoprotection     | Bark       | Ethanolic | Spectrophotometric (in vitro) | SPF: 6.26 ± 0.28 | -    | Almeida-Andrade et al. [28] |
|                     | Bark       | Ethanolic | SPF (in vitro) DSC and FT-IR | SPF: 6 UVB | -    | Lima-Saraiva et al. [27] |
| Preserving agent    | Leaf       | Hydroalcoholic | Spectrophotometric (in vitro) | - | - | Fernandes et al. [46] |
| (Biomphalaria glabrata) |         |         |                      |              |      |          |
| Larvicidal          | Bark       | Hydroalcoholic | Ethan Acetate         | LC50: 68 µg/mL | -    | Santos et al. [46] |
| (Aedes aegypti)     | Bark       | Hexane   | Chloroform            | LC50: 73 µg/mL | -    | Santos et al. [46] |
|                     | Seed       | Ethanolic | WHO (in vivo)          | FC strain: 100% SS strain: 100% | FC strain: 580.9 µg/mL | Souza et al. [45] |
|                     | Seed       | Sodium phosphate buffer | WHO (in vivo)          | 100% of dead | -    | Barbosa et al. [47] |
| Pupicidal           | Seed       | Ethanolic | WHO (in vivo)          | FC strain: 100% | SS strain: 100% | Souza et al. [45] |
| (Aedes aegypti)     | Seed       | Sodium phosphate buffer | WHO (in vivo)          | 100% of dead | -    | Barbosa et al. [47] |
| Ovicidal            | Seed       | Ethanol   | WHO (in vivo)          | FC strain: 5.7% | SS strain: 0% | Souza et al. [45] |
| (Aedes aegypti)     | Seed       | Sodium phosphate buffer | WHO (in vivo)          | ODI25: 25.44 | ODI50: 51.10 | Barbosa et al. [47] |
| Anti-inflammatory   | Bark       | Hydnateanolic | Carrageenan (in vivo) | EAF: 100 mg/kg Agal: 10 mg/kg | -    | Santos et al. [18] |
|                     | Root Bark  | Methanolic | Carrageenan (in vivo) | - | - | Moreira et al. [19] |
|                     | Heartwood  | Methanolic | Carrageenan (in vivo) | - | - | Moreira et al. [19] |
Table 7. Cont.

| Biological Activity | Plant Part | Extract | Method (Study Design) | Main Results | IC50 | Reference |
|---------------------|------------|---------|-----------------------|--------------|------|-----------|
| Antinociceptive     | Bark       | Hydroethanolic | Formalin-induced licking (in vivo) and paw edema (in vivo) | EAF: 40% less pain. HEE: 40% less pain | - | Santos et al. [18] |
|                     | Root Bark  | Methanolic | Formalin-induced licking (in vivo) | - | - | Moreira et al. [19] |
| Anti-hemolytic      | Heartwood  | Methanolic | Formalin-induced and paw edema (in vivo) | 43.84% ± 0.02 | - | Lima-Saraiva et al. [27] |
|                     | Bark       | Ethanolic | Cruz-Silva et al., 2000 (in vitro) | - | 92.66 mg/mL | Sette-de-Souza et al. [23] |
|                     | Bark       | Ethanolic | Cruz-Silva et al., 2000 (in vitro) | - | 50.27 mg/mL | Sette-de-Souza et al. [24] |
| Enzymatic inhibitor | Seed       | Sodium phosphate buffer | Trypsin: 282.33 Chymotrypsin: 90.42 Proteases: 141.17 Amylase: 26.50 | - | - | Barbosa et al. [47] |

A sun Protection Factor of 6 UVB was observed for the ethanolic extract of the bark of S. brasiliensis [27]. The bark extract of the plant can also be used in photoprotective formulations since it has preservative aspects, according to the analytical methods used [48].

Molluscicidal and larvicidal activities were observed in the study with S. brasiliensis bark. Through the method using Biomphalaria glabrata, it was possible to observe that the chloroform fraction of the ethanolic extract resulted in an LC50 of 68 µg/mL, and an ethyl acetate fraction of 73 µg/mL [46]. The larvicidal activity was also observed against Aedes aegypti larvae using the method recommended by the World Health Organization (WHO) for the ethyl acetate (LC50: 345 µg/mL), hexane (LC50: 527 µg/mL), and chloroform (LC50: 583 µg/mL) fractions [46]; while the ethanolic extract of the seeds was able to eliminate A. aegypti larvae (field-collected larvae-LC50: 580.9 µg/mL; insecticide-susceptible larvae-LC50: 661.6 µg/mL) [45]. The pupicidal potential of the ethanolic extract of the seeds was also evaluated, being described as an excellent activity, both for pupae collected in the field of A. aegypti (LC50: 32.9 µg/mL), and for those susceptible to insecticide (LC50: 40.6 µg/mL) [45]. In another study, Barbosa et al. [47] studied the larvicidal activity of the crude extract of S. brasiliensis seeds, using the Konishi et al. (2008) adapted and WHO (2005) adapted methods. The authors observed 100% death against L1 and L4 Aedes aegypti larvae, obtained in 24 h, LC50 of 6.01 mg/mL and 6.14 mg/mL and in 48 h LC50 of 5 mg/mL and 1 mg/mL, respectively.

The nociceptive activity was verified by formalin-induced licking behavior and/or through paw edema [18,19]. The hydroethanolic extract of S. brasiliensis bark and its ethyl acetate fraction reduced the licking time of mice by 40% when applied 30 mg/kg [18].

The anti-hemolytic activity was observed in three studies. The ethanolic extracts of the bark (n = 2; 66.66%) obtained the following results: 43.83% [27] inhibition of erythrocyte hemolysis, while the other one showed the IC50 (maximum concentration to obtain 50% inhibition) 50.27 mg/mL [24] as a result. The hydroalcoholic extract of the barks (n = 1; 33.33%) resulted in IC50 92.66 mg/mL [23].

4. Discussion

This review reports on the geographical distribution, ethnopharmacological use, biological activities, toxicology, and pharmacology of Schinopsis brasiliensis. This plant treats some health problems, mainly in the Caatinga population. The results of the ethnobotanical surveys show variability in the use of parts of the plant to treat several diseases. The difference in indications of use can be explained by the diversity of bioactive molecules found in S. brasiliensis, considering that the environmental conditions, such as temperature, soil, and humidity, directly impact the chemical composition of the plants.
This work observed that most specimens of *S. brasiliensis* identified in Brazil were from the Caatinga Biome. However, the species is reported to be found in the Chaco (Bolivia and Paraguay) and the Brazilian Cerrado, up to near latitude 20°S. Despite this finding, there is no specific information regarding the population density of *S. brasiliensis* in this region [3].

This location of *S. brasiliensis* may explain the concentration of studies in the Caatinga Biome, a large natural region, being the only exclusively Brazilian biome [49]. It has only two most expressive climates: the rainy period and the dry period [38]. These environmental stress factors can directly interfere with producing the plant’s secondary metabolites [50], resulting in several applications.

The great diversity of phytocompounds present in *S. brasiliensis* may be related to the indications of popular use. The phytochemical characterization of *S. brasiliensis* reveals numerous bioactive molecules belonging to several metabolic classes with reported biological activities. Secondary metabolites act by retarding and/or inhibiting the action of free radicals. The observed antioxidant capacity is probably due to the high content of compounds, such as flavonoids, tannins, and phenolic acids. These compounds could donate electrons, thus stabilizing free electrons, in addition to inactivating superoxide anions and peroxide radicals [51].

Tannins have astringent properties, precipitating proteins, and being favorable for antibacterial and antifungal effects [52]. Once administered via the oral route, they promote antidiarrheal and antiseptic effects. Due to the tannin-protein/polysaccharides complex, formed in the precipitation of proteins, creating a protective layer [52], they may exert a healing effect [53]. Thus, the presence of tannins [10,23,24,27–30,33,38], such as corilagin [39], in *S. brasiliensis* may explain the use of the plant to treat diarrhea [9,12,13], stomach pain [37], verminosis [36], infection [11], and fracture [13]. Phenolic compounds are related to antioxidant activities, pharmacological activities, modulation of different enzymes, interactions with receptors, and cell cycle regulations [54].

Flavonoids are compounds that can inhibit or retard enzymatic actions, characterizing their antioxidant action [55]. Their anti-inflammatory potential is associated with the inhibition of enzymes [56] such as cyclooxygenase (COX), lipoxygenase [57], and the inhibition of COX-2 and nitric oxide synthase [58]. Recently, the affinity between some *S. brasiliensis* phytocompounds and COX-1, COX-2, and LOX were evaluated, showing a promising anti-inflammatory activity [19]. Thus, flavonoids may have anti-inflammatory, antioxidant, antiallergic, antiviral, antithrombotic, and anticarcinogenic actions [55,59]. Catechins and derivatives found in *S. brasiliensis* extracts may be related to these described activities. Thus, this explains why in folk medicine *S. brasiliensis* is used to treat diseases of the respiratory tract [9,12,14–17], earache [36], toothache [36], inflammation [9–11], menstrual cramps [11], and fractures [9,13,16].

Because analgesic and anti-inflammatory drugs have significant adverse effects, new prototype drugs are of great interest to the scientific community. Terpenes are secondary metabolites, best known for their action on the Central Nervous System (sedative, tranquilizing, anticonvulsant, anxiolytic, and nociceptive effects). These pharmacological activities are similar to opioids [60–62]. In addition, terpenes are good antimicrobial agents through their ability to permeabilize and depolarize the cytoplasmic membranes of microorganisms. *S. brasiliensis* is rich in terpenes, such as myrcene, α-pinene and linalool. Therefore, one can associate the activity of terpenes with the use for sore throat [9], earache [36], toothache [36], pain in the nerves and spine [17], pain in the stomach and liver [37], reported in ethnobotanical surveys. In addition, terpenes can be attributed to nociceptive activity in rats [18,19].

Saponins are related to the defense mechanism of plants, being found in tissues that are more susceptible to attacks by fungi, insects, and bacteria [63]. They can alter membrane permeability related to ichthyotoxic and molluscicidal activities [64]. The literature reports their use as expectorants and diuretics [64] and their ingestion for stool hardening without affecting intestinal motility [65]. Thus, the saponins present in *S. brasiliensis* may justify its popular use for coughs [12,13,15], influenza [9,13–17,66], cold [9,14], diarrhea [9,12].
Moreover, this class of phytocompounds can justify the results found against *Biomphalaria glabrata* [46] and *Aedes aegypti* [45–47]. The replacement of synthetic insecticides has become a necessity, mainly related to pest resistance to these products. Besides this issue, to control populations of disease vectors such as mosquitoes, for example, larvicidal and pupicidal activities are necessary. Another critical situation is that some mollusks can be part of the biological cycle of helminths—hence the need to control these animals.

The importance of the species and its use for therapeutic purposes is observed since these phytochemical compounds presented have different biological activities.

5. Conclusions and Perspectives

We noticed that *S. brasiliensis* is used mainly by communities in the Northeast of Brazil, especially in the Caatinga, to treat various diseases. The traditional use of *S. brasiliensis* varies according to the part and the community studied. However, the difference in these reports can be attributed to the richness of bioactive compounds present in the plant.

On the other hand, the pharmacodynamic and pharmacokinetic properties of *S. brasiliensis* extracts have not been determined. Thus, future investigations are necessary to determine these parameters to understand the bioavailability of the phytocompounds from *S. brasiliensis*. Finally, it is essential to highlight the need for future studies to explore and elucidate the mechanisms of action of these phytocompounds.

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