



PHARMACOBOTANICAL AND PHYTOCHEMICAL STUDY OF THE LEAVES OF *Gallesia integrifolia* (SPRENG.) HARMS COLLECTED IN SÃO LUÍS, MARANHÃO

Derek Klinger Buás Pinto¹

Joubertth Vieira Ferreira²

Elian Chaves Ribeiro³

Maria Cristiane Aranha Brito⁴

José Fábio França Orlando⁵

Denise Fernandes Coutinho⁶

Wellyson da Cunha Araújo Firmo⁷

ABSTRACT

Objective: Carry out a morpho-anatomical and phytochemical study of the leaves of *Gallesia integrifolia* (Spreng.) Harms.

Theoretical Framework: *G. integrifolia* (pau-d'álho) is a plant from the Phytolaccaceae family, native to the Amazon and Cerrado biomes, used in folk medicine for inflammatory and infectious diseases.

Method: The leaves collected in São Luís, Maranhão, identified and registered in the Maranhão Herbarium. The morphological characteristics were analyzed with the naked eye, and the anatomical study involved transverse and paradermal sections in the median region of the leaves, where they were stained and analyzed under an optical microscope. The Hydroalcoholic Extract (HaE) and Aqueous Extract (AqE) were prepared for phytochemical analysis, evaluating the presence of phenols and tannins, flavonoids, saponins and alkaloids.

Results and Discussion: The leaves have a lanceolate shape, symmetrical base, acuminate apex, entire margin and limb and peninnervian venation. Under microscopy, the hypostomatic leaves, with anomocytic stomata, epidermal cells with sinuous anticlinal walls, glandular trichome, dorsiventral mesophyll, biconvex central rib, with two collateral vascular bundles with fiber sheaths, one smaller on the upper surface and the other in an arc on the abaxial face, with parenchyma in the central region of this rib. In HaE and AqE, phenols, tannins, some types of flavonoids and alkaloids and the absence of triterpenes and saponins were observed.

Research Implications: The therapeutic potential of the plant species favors pharmacobotanical and phytochemical studies, as it enables the identification, authenticity of the raw material and influences the study of pharmacological activities.

Originality/Value: This study contributes to the literature regarding information on the morpho-anatomical characteristics and the presence of classes of secondary metabolites of *G. integrifolia*.

¹ Universidade Federal do Maranhão, São Luís, Maranhão, Brazil. E-mail: ddklg377@gmail.com
Orcid: <https://orcid.org/0000-0001-5022-537X>

² Universidade Federal do Maranhão, São Luís, Maranhão, Brazil. E-mail: joubertth.ferreira@discente.ufma.br
Orcid: <https://orcid.org/0009-0007-2429-1892>

³ Universidade Federal do Maranhão, São Luís, Maranhão, Brazil. E-mail: elian_chavesribeiro@hotmail.com
Orcid: <https://orcid.org/0009-0009-3812-7385>

⁴ Centro Universitário Mauricio de Nassau, São Luís, Maranhão, Brazil. E-mail: tiane91@hotmail.com
Orcid: <https://orcid.org/0000-0002-6979-8773>

⁵ Universidade Estadual da Região Tocantina do Maranhão, Imperatriz, Maranhão, Brazil.
E-mail: fabio.franca@uemasul.edu.br Orcid: <https://orcid.org/0000-0002-6402-6192>

⁶ Universidade Federal do Maranhão, São Luís, Maranhão, Brazil. E-mail: denise.coutinho@ufma.br
Orcid: <https://orcid.org/0000-0002-5665-9280>

⁷ Universidade Estadual da Região Tocantina do Maranhão, Imperatriz, Maranhão, Brazil.
E-mail: wellyson.firmo@uemasul.edu.br Orcid: <https://orcid.org/0000-0002-6979-1184>



Keywords: Biotechnology, Quality Control, Phytochemical Compounds, Medicinal Plants.

ESTUDO FARMACOBOTÂNICO E FITOQUÍMICO DAS FOLHAS DE *Gallesia integrifolia* (SPRENG.) HARMS COLETADAS EM SÃO LUÍS, MARANHÃO

RESUMO

Objetivo: Realizar um estudo morfo-anatômico e fitoquímico das folhas de *Gallesia integrifolia* (Spreng.) Harms.

Referencial Teórico: *G. integrifolia* (pau-d'álho) é uma planta da família Phytolaccaceae, natural dos biomas amazônico e cerrado, usada na medicina popular para doenças inflamatórias e infecciosas.

Método: As folhas coletadas em São Luís, Maranhão, identificadas e registradas no Herbário do Maranhão. As características morfológicas foram analisadas à vista desarmada, e o estudo anatômico, fez-se os cortes transversais e parâdermicos na região mediana das folhas, onde foram corados e analisados em microscópio óptico. Foram preparados o Extrato Hidroalcoólico (EHa) e o Aquoso (EAq) para análise fitoquímica, avaliando a presença de fenóis e taninos, flavonoides, saponinas e alcaloides.

Resultados e Discussão: As folhas apresentam formato lanceolado, base simétrica, ápice acuminado, margem e limbo inteiro e nervação penínervia. Na microscopia, as folhas hipostomáticas, com estômatos anomocíticos, células epidérmicas com paredes anticlinais sinuosas, tricoma glandular, mesófilo dorsiventral, nervura central biconvexa, com dois feixes vasculares colaterais com bainha de fibras, sendo um menor junto a face superior e outro em arco na face abaxial, havendo parênquima na região central dessa nervura. No EHa e EAq observou-se, fenóis, taninos, alguns tipos de flavanoides e alcaloides e ausência de triterpenos e saponinas.

Implicações da Pesquisa: O potencial terapêutico da espécie vegetal favorece o estudo farmacobotânico e fitoquímico, pois possibilita a identificação, a autenticidade da matéria-prima e influência o estudo de atividades farmacológicas.

Originalidade/Valor: Este estudo contribui para a literatura no que tange nas informações sobre as características morfo-anatômica e na presença de classes de metabólitos secundários de *G. integrifolia*.

Palavras-chave: Biotecnologia, Controle de Qualidade, Compostos Fitoquímicos, Plantas Medicinais

ESTUDIO FARMACOBOTÁNICO Y FITOQUÍMICO DE HOJAS DE *Gallesia integrifolia* (SPRENG.) HARMS RECOLECTADAS EN SÃO LUÍS, MARANHÃO

RESUMEN

Objetivo: Realizar un estudio morfoanatómico y fitoquímico de las hojas de *Gallesia integrifolia* (Spreng.) Harms.

Marco Teórico: *G. integrifolia* (pau-d'álho) es una planta de la familia Phytolaccaceae, originaria de los biomas Amazonas y Cerrado, utilizada en la medicina popular para enfermedades inflamatorias e infecciosas.

Método: Las hojas recolectadas en São Luís, Maranhão, identificadas y registradas en el Herbario de Maranhão. Las características morfológicas se analizaron a simple vista y el estudio anatómico involucró cortes transversales y parâdermicos en la región media de las hojas, donde fueron teñidas y analizadas al microscopio óptico. Se prepararon el Extracto Hidroalcohólico (EHa) y el Extracto Acuoso (EAc) para análisis fitoquímicos, evaluando la presencia de fenóles y taninos, flavonoides, saponinas y alcaloides.

Resultados y Discusión: Las hojas tienen forma lanceolada, base simétrica, ápice acuminado, margen y limbo entero y venación peninnerviana. Al microscopio se observan las hojas hipostomáticas, con estomas anomocíticos, células epidérmicas con paredes sinuosas anticlinales, tricoma glandular, mesófilo dorsiventral, costilla central biconvexa, con dos haces vasculares colaterales con vainas de fibras, una más pequeña en el haz y otra en arco en el la cara abaxial, con parênquima en la región central de esta costilla. En EHa y EAc se observaron fenóles, taninos, algunos tipos de flavonoides y alcaloides y ausencia de triterpenos y saponinas.



Implicaciones de la investigación: El potencial terapéutico de las especies vegetales favorece los estudios farmacobotánicos y fitoquímicos, ya que permite la identificación, autenticidad de la materia prima e influye en el estudio de las actividades farmacológicas.

Originalidad/Valor: Este estudio contribuye a la literatura sobre información sobre las características morfoanatómicas y la presencia de clases de metabolitos secundarios de *G. integrifolia*.

Palabras clave: Biotecnología, Control de Calidad, Compuestos Fitoquímicos, Plantas Medicinales.

RGSA adota a Licença de Atribuição CC BY do Creative Commons (<https://creativecommons.org/licenses/by/4.0/>).



1 INTRODUCTION

Gallesia integrifolia (Spreng.) Harms is a native Brazilian plant species, widely present from the Amazon to the Cerrado, which is part of the Phytolaccaceae family, which ranges from grasses to large trees. *G. integrifolia* comprises large trees with heights ranging from 15 to 30 m and its trunk has a diameter of 70 to 140 cm. Its flowering is between February and April and its fruits ripen between September and October (Sydor *et al.*, 2022).

Its main characteristic is the strong smell of garlic on all organs, but it stands out on the leaves and bark, especially when green. This characteristic justifies their main popular names such as stink stick, garlic stick or garlic stick. They also have names derived from indigenous languages such as guararema, ubaeté. The smell of garlic is due to the presence of natural substances such as sulfur present in the species (Furtado *et al.*, 2022).

Ethnopharmacological studies report numerous uses of parts of *G. integrifolia*, in neoplasms, such as prostate tumors (Lorenzi, 2002); the use of its leaves and stalk to control arterial hypertension, as well as reduce lipid levels (Feijo, 2008), still used to treat asthma and bronchitis or infectious diseases (Arunachalam *et al.*, 2016) and inflammatory such as rheumatism and arthritis (Bortolucciet *al.*, 2022).

Chemical studies have already demonstrated the presence of porphyrins, a diterpene, triterpenes (Neves, 2012), saponins, simple phenolic compounds, flavonoids and sesquiterpenes (Arunachalam *et al.*, 2017), as well as alkaloids, essential oils, tannins and coumarins (Souza *et al.*, 2020).

Considering the potential for medicinal use, an incorrect identification of the raw material of *G. integrifolia* for the production of phytotherapies has as consequence the use of an inappropriate pharmaceutical input, which not only does not present the desired therapeutic effect, can also promote undesirable effects for presenting toxic components (Costa, 2021).



Hence, the need to carry out pharmacobotanical studies that make it possible to identify macro- and microscopic characteristics allowing the quality control of the species, and its safe use in research and therapy (Oliveira & Akisue, 2009).

The Brazilian Pharmacopeia emphasizes the importance of the morpho-anatomic description of plant species as a prerequisite for the identification of plant drugs, emphasizing the relevance of this type of research to perform quality control of plant material for use by industries or manipulation pharmacies, aiming at producing medicines, inputs, or other derivative of interest to society, ensuring the use of the correct species (Gilbert *et al.*, 2022).

In this context, this study aimed to conduct a morpho-anatomic and phytochemical study of *G. integrifolia* leaves, enabling them to be used as criteria of authenticity in the correct characterization of this species, ensuring the use of the correct species and contributing to its quality control and possible pharmacological studies with the plant species.

2 METHODOLOGY

The species *G. integrifolia* was collected during the month of June 2023, in the rural area of the city of São Luís, Maranhão (2°36'38.3"S 44°12'57.8"W) in the late afternoon. Its exsiccatas were prepared and sent for identification in the Herbarium of Maranhão (MAR) of the Federal University of Maranhão, where it was deposited under registration number of the Tombo MAR 13.900.

For the description morpho-anatomical, adult leaves were used, collected from the 3rd to 5th knots of the branches of the species. For the macroscopic description, the leaves were analyzed with the unarmed view, observing the following characteristics: phyllotaxy, composition, color, size, consistency, contour, apex, base, margin and nervation.

For the description of the anatomical (microscopic) characteristics, cross-sectional and paraderical cuts were made in the median region of the leaf limbus with the aid of stainless steel sheets. The cuts were then discolored with 20% sodium hypochlorite solution and washed in distilled water and stained with astra blue and 0.5% basic fuchsin. The slides were mounted in distilled water and analyzed under an optical microscope (Oliveira & Akisue, 2009).

For the preparation of the extracts of *G. integrifolia*, the cold maceration process was used. For the preparation of the Aqueous Extract (EAq), 200g of the vegetable material was used in distilled water solvent in the ratio 1:10. After 24 hours, the mixture obtained was vacuum-filtered, concentrated in a vacuum oven and subsequently freeze-dried. For the Hydroalcoholic Extract (aH), 100g of the previously ground plant material was used, with



solvent extractor ethanol P.A 70% (v/v) following the ratio 1:10 for 7 days, with daily stirring, under cover of light wrapped in aluminum foil. The mixture obtained after 7 days was vacuum filtered and concentrated in rotary evaporator under reduced pressure, after this process the extract was lyophilized for further analysis (Harborne, 1998). At the end of the processes, the hydroalcoholic and aqueous extracts were obtained in the form of a dry powder.

The AEq and aH were submitted to phytochemical tests, following the methodology of Matos (2009). The tests carried out evaluated the presence of phenols and tannins (reaction with ferric chloride), flavonoids (pH variation test), saponins (foam test) and alkaloids (identification with Dragendorff, Hager and Mayer).

3 RESULTS AND DISCUSSIONS

Data on the anatomy of *G. integrifolia* are limited, and no descriptive studies on the anatomy of the species were found after the work of Oliveira and Akisue (2009). What is to be seen is that the studies focused on this plant species were concerned with making comparisons as to the characteristics of germination and the influences of light and shading, as pointed out by Feijo (2008).

Most of the published papers on *G. integrifolia* deal with the analysis of its substrates and biological applications, such as essential oil of several different organs from fruits, leaves and bark, and crude extracts using various solvents.

For this reason, due to the limited volume of specific published work on the anatomy of the species *G. integrifolia*, for the purpose of comparing anatomical characteristics, studies were used in this work referring to other species, of the same family, since as for the family Phytolaccaceae the volume of information is much greater, especially the species *Petiveria alliacea* Linn stands out.

The species *G. integrifolia* has lanceolate-shaped, bright green leaves on both sides, being stronger on the adaxial face, measuring 16 to 24 cm in length and 6 to 10.5 cm in width in the median region. It has a symmetrical base, an acuminate apex; a smooth, whole margin; a penile vein and a short petiole (Figure 1).



Figure 1

Characteristic of the leaves of Gallesia integrifolia (Spreng.) Harms.



The work with the most detailed description of the macro- and microscopic characteristics of *G. integrifolia* is that of Oliveira and Akisue (2009), and the findings in this work corroborate those of these researchers, as dorsiventral mesophyll, presenting pallidatic tissue, areas with sclera-chemic fibers demonstrating support of the epidermis and trichomes.

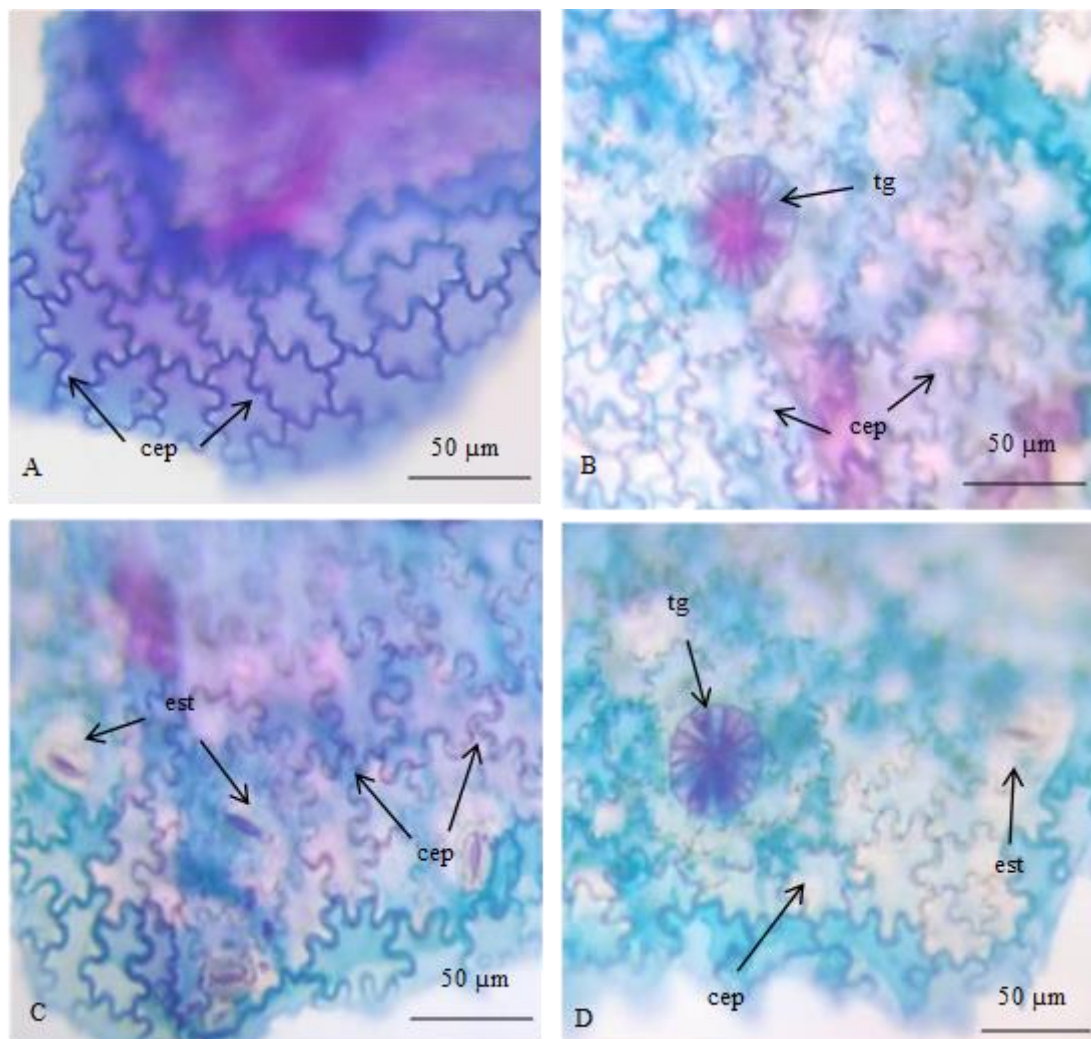
Piva *et al.* (2019) have similarly found similar features in their sample of *G. integrifolia*, such as the presence of developed cuticles, phloem, xylem and parenchyma, pallidavoids, multi-layered cortex as well as sclera fiber sheath.

The epidermis, in front view, has cells with sinuous anticline walls on both sides. Glandular trichomes have been observed on both sides of the epidermis. The stomata are of the anomocytic type and are restricted to the underside, characterizing the leaf as hypostomatic (Figure 2 A-D).



Figure 2

Leaf blade and epidermis in front view of Gallesia integrifolia (Spreng.) Harms.



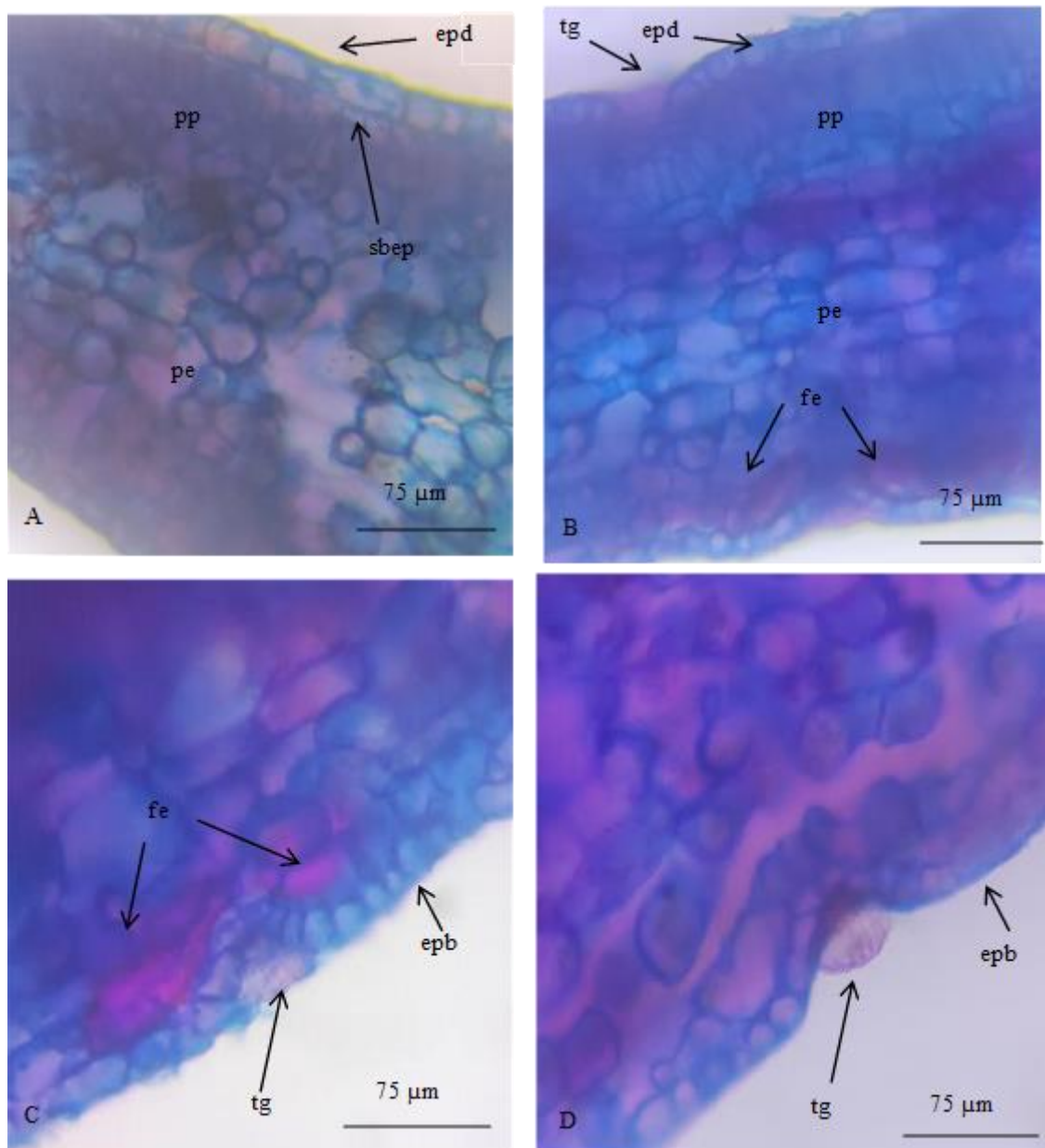
A-B: adaxial face. C-D: Abaxial face. B: detail of the glandular trichoma of the adaxial face; D: detail of the glandular trichoma on the abaxial face and of the anamocytic stomata. Key: zip = epidermal cell, est = stomata, tg = glandular trichoma.

In the cross sections, the epidermis of the adaxial face shows subepidermis in some areas. The epidermis of the abaxial face is unistratified. A thin cuticle has been observed, and gland trichomes are found in epidermal depressions. The mesophyll of this leaf is dorsiventral, with a layer of pallidic tissue and several of spongy tissue. The pallidic tissue is short. Along the abaxial face of the epidermis, in this region of the mesophyll, there were some areas of scleral fibers that seem to be supporting the epidermis and the trichomes (Figure 3 A-D).



Figure 3

Leaf blade in cross view of Gallesia integrifolia (Spreng.) Harms.



A-B: dorsiventral mesophyll. C-D: mesophyll, with detail of glandular tricoma. Legend: pp = palliationary parenchyma, pe = spongy parenchyma, tg = glandular tricoma, epd = adaxial epidermis, sbep = subepidermis, b = abaxial epidermis, fe = sclerenchymal fibers.

The median rib is biconvex in shape, with the upper convexity being discrete. Below the epidermis, scleral fibers are observed, being more condensed on the adaxial face and forming one or two layers on the abaxial face.

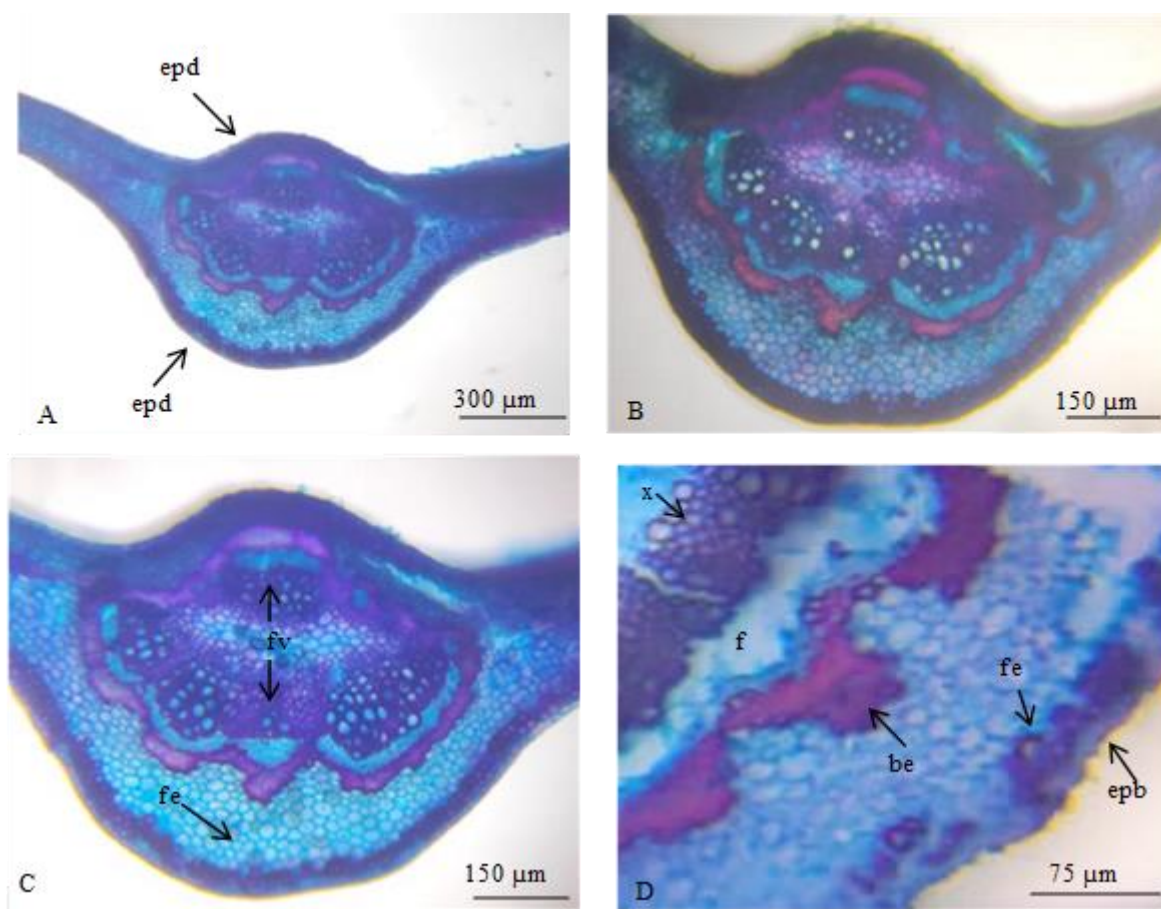
Colenchyma, which is common on median ribs, cannot be observed by the presence of fibers. Then there is common parenchyma which is more developed on the abaxial face. There are 2 bicollateral vascular bundles that are joined by a sheath of sclerotic fibers.



The smaller beam faces the adaxial face and the other one closer to the abaxial face, is arc-shaped with undulations, and in some areas the beams appear to be separated. There is a parenchyma in the center of the spinal cord, similar to a parenchyma of the spinal cord. Between these two main beams, smaller beams can be observed, also joined by the sheath of sclerotic fibers that are forming a characteristic design (Figure 4 A-D).

Figure 4

Central rib in cross view of Gallesia integrifolia (Spreng.) Harms.



A: Overview of the central rib. B-C: details of the central rib. D: detail of the underside. Key: epd = adaxial epidermis, epb = abaxial epidermis, fe = sclera fibers; be = sheath of sclera fibers, x = xylem, f = phloem, fv = vascular bundle, p = parenchyma.

The presence of anomocytic-type stomata resembles those observed in other species, such as *Rivina humis* Linn (Pugialli & Marquete, 1989) and *P. alliacea*(Rochaet al.,2006), which are restricted to the abaxial face only.

Other features of the Phytolaccaceae also appear in *G. integrifolia*, such as the presence of a pallidic parenchyma and stomata at the same level as the other epidermal cells.



The positioning of the stomata on the underside of the leaves (abaxial face) classifies it as hypostomatic according to the characterization of Metcalfe and Chalk (1950), this particularity relates to environmental conditions, being often present on the upper face in aquatic plants, and on the lower plants adapted to dry environments, since the stomata are organs related to gas exchange and transpiration of plants (Pacheco *et al.*, 2021), such relationship makes sense since the environment of the sample collection in rural area of São Luís consisted of more xeric (dry).

The presence of glandular trichomes in *G. integrifolia* leaves indicates that the species has developed the ability to secrete substances in order to defend itself from aggression or attract pollinators, among the substances stand out the essential oils: terpenes characteristic as volatile oily liquids, with a strong aroma, which contribute to the odor (essence) peculiar to some plant species (Machado and Fernandes Junior, 2011) and this is the main characteristic of *G. integrifolia*¹, even responsible for its popular names.

Numerous studies have confirmed the presence of essential oil in *G. integrifolia*, in various organs such as leaves (Akisue *et al.*, 1984), in the bark (Barbosa *et al.*, 1999), and even flowers (Furtado *et al.*, 1922).

Since the city of São Luís is located in one of the three main ecotones of Brazil: Cerrado-Amazônia (Santos, 2022), the uniqueness of abiotic factors such as nutrients, temperature variation, abundance of water resource directly influence the formation of species and synthesis of secondary metabolites (Gobbo-Neto & Lopes, 2007), this fact also relates to the position of stomata on the underside, a way to avoid excessive water loss, since even the collection site is a coastal city, some places, especially those farther from the coast may experience periods of water deprivation, especially during periods of drought.

The uniqueness of a transitional biome is also related to the presence of glandular trichomes, since these mainly serve the purpose of secreting exudates capable of protecting the plant from aggressive pathogens such as bacteria and fungi (Wang *et al.*, 2021), these having an environment conducive to their proliferation in an environment with such biodiversity.

In relation to the phytochemistry of EAq and aH as shown in Table 1, the presence of classes of secondary metabolites such as phenols and tannins, flavones, xanthonenes, flavonols and flavonoids were identified in both extracts. As for anthocyanidins and anthocyanins, triterpenes and saponins, they were not observed in both extracts.



Table 1

Phytochemical evaluation of secondary metabolites of extracts of Gallesia integrifolia (Spreng.) Harms.

Secondary metabolites		EAq	EHa
Phenols		+++	+++
Tannins		+++	+++
Flavonoids	Antocyanidines and Antocyanines	-	-
	Flavonois, Flavonois and Xanthones	+++	+++
	Chalcones	++	+
	Flavonoids	+++	+++
	Leukoanthocyanidins	-	+
	Catechins	++	+
	Flavanones	++	++
Triterpenes		-	-
Alkaloids		+++	+
Saponins		-	-

Key: +++ = strongly positive reaction; ++ = moderately positive reaction; + = weakly positive reaction; - = negative reaction. EAq = Aqueous extract; EHa = Hydroalcoholic extract.

The relevance of phytochemical studies mainly translates into identifying the chemical compounds present in the species under study, identifying the relevant secondary metabolite classes in the quality of the medicinal raw material and in prospecting for biodiversity or bioprospecting. Secondary metabolites have relevant biological activities, the greatest benefit of which is found in the numerous pharmacologically active substances (Simões, 2001). As observed in this study the range of secondary metabolite classes, which may be conducive to pharmacological studies.

The presence of alkaloids in the EAq and aH are consistent with the studies of Akisue *et al.* (1986) and Rodrigues *et al.* (2021). A similar phytochemical profile has also been observed in *G. integrifolia* substrates as the essential oil: tannins and coumarins (Carneiro *et al.*, 2014; Souza *et al.*, 2020). Neves (2012) observed substances such as porphyrins, a diterpene, triterpenes; whereas, Arunachalam *et al.* (2017) found saponins, alkaloids, phenolic compounds, flavonoids and sesquiterpenes. A similar phytochemical profile was found in the studies of Ordóñez *et al.* (2020), which observed the presence of alkaloids, flavonoids, steroids, coumarins and sesquiterpenic lactones in the methanolic extract.

The presence of alkaloids in the plant species under study is important due to the importance that this metabolite can present, since there are related biological activities, the anesthetic, analgesic, anti-inflammatory, anticholinergic, neurodepressant, psychostimulant, antimicrobial, muscle relaxant, among other pharmacological activities (Lovato, 2021; Santos *et al.*, 2023).



Phenols and tannins, other metabolic classes observed in the species *G. integrifolia*, have already been related in other studies to antifungal, antibacterial and antiviral, antirheumatic, antitumor and antitussive activities (Arnoso *et al.*, 2019).

The phytochemical profile of AEq and aSH are suggestive of antimicrobial activity due to the phytochemical constituents present, such as tannins, flavonoids and alkaloids and phenols, which may be associated with antioxidant and antimicrobial activity. Although there are similarities between this study and Pereira *et al.* (2022) and Nogueira *et al.* (2021), there were differences in the phytochemical profile in relation to the absence of saponins.

In the light of the above, it is important to point out that the quantity of secondary metabolites and the specific type in each medicinal plant varies depending on the time of year, time of collection, soil conditions and also with factors inherent to the plant (Noldin *et al.*, 2003).

4 CONCLUSION

G. integrifolia studied in this work showed that many of its anatomical features resemble other species of the same family Phytolaccaceae, sharing peculiarities with samples of the same species, but collected elsewhere.

In this way, by recognizing these individual characteristics of the species, one can identify with greater certainty which peculiarities help to determine a rigorous control of quality in obtaining the correct raw materials, as well as reinforcing the possibility of the presence of relevant secondary metabolites, and thus can guide for research into pharmacological activities and obtaining bioproducts.

REFERENCES

- Akisie, M. K., Akisie, G., & Oliveira, F. D. (1986). Caracterização farmacognóstica de pau d'alho *Gallesia integrifolia* (Spreng.) Harms. *Revista Brasileira de Farmacognosia*, 1, 166-182.
- Akisie, G., Wascky, R., Akisie, M. K., & Oliveira, F. (1984). Composição química do óleo essencial de *Gallesia integrifolia* (Spreng) Harms Phytolacaceae. *Rev Farm Bioquim Univ Sao Paulo*, 20, 145-257.
- Arnoso, B. J. M., Costa, G. F., & Schmidt, B. (2019). Biodisponibilidade e classificação de compostos fenólicos. *Nutrição Brasil*, 18(1), 39-48.



- Arunachalam, K., Ascêncio, S. D., Soares, I. M., Aguiar, R. W. S., Silva, L. I., Oliveira, R. G. *et al.* (2016). *Gallesia integrifolia* (Spreng.) Harms: in vitro and in vivo antibacterial activities and mode of action. *Journal of Ethnopharmacology*, 184, 128-137.
- Arunachalam, K., Balogun, S. O., Pavan, E., Almeida, G. V. B., Oliveira, R. G., Wagner, T. *et al.* (2017). Chemical characterization, toxicology and mechanism of gastric antiulcer action of essential oil from *Gallesia integrifolia* (Spreng.) Harms in the in vitro and in vivo experimental models. *Biomedicine & Pharmacotherapy*, 94, 292-306.
- Barbosa, L. C. A., Demuner, A. J., Teixeira, R. R., & Madruga, M. S. (1999). Chemical constituents of the bark of *Gallesia gorazema*. *Fitoterapia*, 70(2), 152-156.
- Bortolucci, W. D. C., Raimundo, K. F., Fernandez, C. M. M., Calhelha, R. C., Ferreira, I. C., Barros, L. *et al.* (2022). Cytotoxicity and anti-inflammatory activities of *Gallesia integrifolia* (Phytolaccaceae) fruit essential oil. *Natural Product Research*, 36(11), 2878-2883.
- Carneiro, F. M., Silva, M. D., Borges, L. L., Albernaz, L. C., & Costa, J. D. P. (2014). Tendências dos estudos com plantas medicinais no Brasil. *Revista Sapiência: sociedade, saberes e práticas educacionais*, 3(2), 44-75.
- Costa, A. P. D. (2021). A utilização de plantas medicinais na região nordeste do Brasil: uma revisão. (Monografia de Graduação). Universidade Federal de Campina Grande.
- Feijo, N. S. A. (2008). *Crescimento e comportamento fotossintético de Gallesia integrifolia (Spreng.) Harms e Schinus terebinthifolius Raddi sob condições de sombra densa*. (Dissertação de Mestrado) Universidade Estadual de Santa Cruz.
- Furtado, C. H., Carneiro, A. R., Gazim, Z. C., Fernandes Junior, A., Rocha, S. A., Raimundo, K. F. *et al.* (2022). Influência de fatores abióticos no rendimento do óleo essencial da *Gallesia integrifolia* (Spreng.) Harms. *Revista Gestão & Sustentabilidade Ambiental*, 11, 221-237.
- Gilbert, B., Alves, L. F., & Favoreto, R. D. F. (2022). *Monografias de Plantas Medicinais Brasileiras e Aclimatadas: Volume II*. Editora Fiocruz.
- Gobbo-Neto, L., Lopes, N. P. (2007). Plantas medicinais: fatores de influência no conteúdo de metabólitos secundários. *Química nova*, 30, 374-381.
- Harborne, A. J. (1998). *Phytochemical methods a guide to modern techniques of plant analysis*. Springer science & business media.
- Lorenzi, H. (1992). *Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil*. 4 ed. Instituto Plantarum de Estudos da Flora Ltda, Nova Odessa.
- Lovatto, P. B. (2021). *Fitoprotetores botânicos: União de saberes e tecnologias para transição agroecológica*. Editora Appris.
- Machado, B. F. M. T., & Fernandes Júnior, A. (2011). Óleos essenciais: aspectos gerais e usos em terapias naturais. *Cadernos acadêmicos*, 105-127.



- Matos, F.J.A. (2009). *Introdução à fitoquímica experimental*. 3 ed. Fortaleza: Editora da UFC.
- Metcalf, C. R., & Chalk, L. (1950). Anatomy of the Dicotyledons. *Clarendon Press, Oxford*, 2, 1014-1024.
- Neves, F. S. (2012). *Estudo químico e microbiológico de Gallesia integrifolia (Spreng.) Harms. (Phytolaccaceae)*. (Dissertação de Mestrado). Universidade Estadual do Norte Fluminense Darcy Ribeiro.
- Nogueira, M. L. D. O., Lima, L. M., Lemos, A. S. D. O., Diogo, M. A., Souza, T. D. F., Silva, J. P. S. D. *et al.* (2021). *Plantago major* L. (Plantaginaceae) pode ser utilizado como agente antimicrobiano para emprego em produtos para uso oral?. *Revista Fitos*, 15(3), 354-365.
- Noldin, V. F., Cechinel Filho, V., Monache, F. D., Benassi, J. C., Christmann, I. L., Pedrosa, R. C., *et al.* (2003). Composição química e atividades biológicas das folhas de *Cynara scolymus* L.(alcachofra) cultivada no Brasil. *Química nova*, 26, 331-334.
- Oliveira, F., & Akissue, G. (2009). *Fundamentos de farmacobotânica e de morfologia vegetal*. 3 ed. São Paulo: Editora Atheneu.
- Ordóñez, P. E., Mery, D. E., Sharma, K. K., Nemu, S., Reynolds, W. F., Enriquez, R. G. *et al.* (2020). Synthesis, crystallography, and anti-leukemic activity of the amino adducts of dehydroleucodine. *Molecules*, 25(20), 4825.
- Pacheco, F., Lazzarini, L. E., & Alvarenga, I. (2021). Metabolismo relacionado com a fisiologia dos estômatos. *Enciclopédia Biosfera*, 18(36).
- Pereira, A. M. D., Brito, S. A., Anjos, S. D. S., & Lucena, J. D. (2022). Estudo fitoquímico e atividade biológica de *Vitis vinífera*: uma revisão de literatura. *E-Acadêmica*, 3(3), e5633364-e5633364.
- Piva, T. C., Draghi, A. C. A., Guerra, A., & Medri, C. (2019). Descrição Anatômica de *Gallesia Integrifolia* (Spreng.) Harms (Phytolaccaceae). In: *Anais do 63º Congresso Nacional de Botânica*, p. 210.
- Pugialli, H. R. L., & Marquete, O. (1989). *Rivina humilis* L. (Phytolaccaceae), anatomia da raiz, caule e folha. *Rodriguésia*, 41, 35-43.
- Rocha, L. D., Maranhão, L. T., & Preussler, K. H. (2006). Organização estrutural do caule e lâmina foliar de *Petiveria alliacea* L., Phytolaccaceae. *Rev. Bras. Farm.*, 87(3), 98-101.
- Rodrigues, M. L., Lima, V. M., Medeiros, L. S. C., Desiderio, A. F. A., Ferreira, M. C. S., & Borba, H. R. (2021). Prospecção fitoquímica do extrato aquoso e hidroalcoólico das folhas de *Gallesia integrifolia*. In: *Anais do Simpósio Brasileiro de Farmacognosia - XIII SBFgnosia*.
- Santos, C. R. (2022). Diversidade e estrutura do sub-bosque de florestas ecotonais no Maranhão: relações fitogeográficas e influência do meio urbano. (Dissertação de Mestrado). Universidade Federal Rural de Pernambuco.



- Santos, G. D. M., Ferreira, H., Silva, T., & Silva, T. (2023). Alcaloide milonina: atividades biológicas e farmacológicas uma revisão da literatura. *Peer Review*, 5(20), 160-172.
- Simões, C. M. O. (2001). *Farmacognosia: da planta ao medicamento*. UFRGS; Florianópolis: UFSC.
- Souza, E., Santos, P., Peixoto, A., Cocozza, F., & Carneiro Neto, T. F. S. (2020). Essential oils from medicinal plants: production and treatment of respiratory diseases (Comorbidities) in preventing the COVID-19 symptoms. *Revista Brasileira de Agroecologia*, 15(4), 56-68.
- Sydor, B. G., Ramos-Milaré, Á. C. F. H., Pereira, M. B., Brustolin, A. Á., Montaholi, D. C., Lera-Nonose, D. S. S. L. *et al.* (2022). Plants of the Phytolaccaceae family with antimicrobial activity: A systematic review. *Phytotherapy Research*, 36(9), 3505-3528.
- Wang, X., Shen, C., Meng, P., Tan, G., Lv, L. (2021). Analysis and review of trichomes in plants. *BMC plant biology*, 21, 1-11.