

Botanical identification of plants sold as *Hypericum perforatum* L. (St. John's wort) in the informal and formal marketplace in the state of Rio de Janeiro, Brazil

Identificação botânica de plantas vendidas como *Hypericum perforatum* L. (erva-de-São-João) no comércio formal e informal no estado do Rio de Janeiro, Brasil

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ABSTRACT

The present paper aimed to analyze seven samples of *Hypericum perforatum* L., popularly known as St. John's wort, marketed as natural antidepressants, collected from formal and informal markets in different municipalities in the state of Rio de Janeiro, Brazil. Morphological and histological analyses were performed on the samples using standard methods for botanical identification, with the aid of a stereoscopic microscope, and binocular and trinocular light microscopes, in addition to specialized literature containing identification keys for the identification of genera and species of the Asteraceae family. Six of the analyzed samples corresponded to an herbaceous species with capitula, petiolate leaves, and both non-glandular and glandular trichomes, which allowed their identification as *Ageratum conyzoides*. Another sample exhibited characteristics such as glabrous branches, petiolate leaves, a yellowish capitulum, and heteromorphic achene-type fruits, allowing its identification as *Synedrella nodiflora*. Therefore, it was concluded that none of the samples marketed as St. John's wort corresponded to *Hypericum perforatum* L. Consequently, the medicinal claims associated with these plants are invalid, and their use may represent a potential health risk to consumers.

Keywords. Medicinal Plants, *Hypericum perforatum*, Stomata, Trichomes.

RESUMO

O presente trabalho teve como objetivo a análise de sete amostras de *Hypericum perforatum* L., popularmente conhecida como erva-de-São-João, comercializadas como antidepressivos naturais e coletadas em mercados formais e informais de diferentes municípios do estado do Rio de Janeiro, Brasil. Foram realizadas análises morfológicas e histológicas das amostras utilizando metodologia padrão para identificação botânica, com o auxílio de microscópio estereoscópico e microscópios de luz binoculares e trinoculares, além de literatura especializada contendo chaves de identificação para gêneros e espécies da família Asteraceae. Seis das amostras analisadas correspondiam a uma espécie herbácea com capítulos, folhas pecioladas e tricomas glandulares e não glandulares, características que permitiram sua identificação como *Ageratum conyzoides*. Outra amostra apresentou características como ramos glabros, folhas pecioladas, capítulo amarelado e frutos do tipo aquênio heteromórfico, permitindo sua identificação como *Synedrella nodiflora*. Concluiu-se, portanto, que nenhuma das amostras comercializadas como erva-de-São-João correspondia a *Hypericum perforatum* L. Consequentemente, as alegações terapêuticas associadas a essas plantas não são válidas e seu uso pode representar um risco potencial à saúde dos consumidores.

Palavras-chave. Plantas medicinais, *Hypericum perforatum*, Estômatos, Tricomas.

INTRODUCTION

Depression is a serious and increasingly common disease worldwide. According to the Brazilian Ministry of Health¹, the risk factors for the onset of this disease include biochemical and genetic imbalances, endocrine and neurological diseases, anxiety, among others. Considering the side effects, the high cost of conventional medications, and the mistaken belief that herbal medicines will have fewer side effects simply because they are natural, the population has increasingly sought, in recent years, natural-origin medications to treat problems related to depression².

The best-known and widely used plant-based antidepressant medications are phytotherapeutics derived from *Hypericum perforatum* L. (Hypericaceae) and *Piper methysticum* G. Forst. (Piperaceae), popularly known as St. John's wort and kava-kava³, respectively. The species *Hypericum perforatum* L. stands out for its use in the treatment and prevention of various diseases, with nephroprotective, antioxidant, antifungal, anxiolytic, antiviral effects, and healing activities⁴. *H. perforatum* is an herbaceous species native to Europe, Western Asia, and North Africa.

There are approximately 400 species in the genus *Hypericum*, with *H. perforatum* being the most well-known. For over 200 years, St. John's wort has been used to treat wounds and gastrointestinal disorders. However, in the 19th century, it began to be indicated for the treatment of epilepsy, and in the 20th century, for the treatment of depression⁴.

The adulteration of herbal products is a widespread problem internationally. In Brazil, on average, 68% of herbal medicines are adulterated, posing a challenge to public health. In this context, the correct identification of plant species is essential to guarantee the safety, efficacy, and purity of natural products, herbal medicines, or spices, thus preventing adulteration through incorrect substitutions with more toxic species or those of lower commercial value⁵. Therefore, the objectives of this work were to acquire the botanical material, *Hypericum perforatum* L. (St. John's wort), from the formal and informal markets in different municipalities of the state of Rio de Janeiro, Brazil, performing botanical identification through morphological and histological analyses, and correlating the results obtained with information available in the specialized literature.

MATERIAL AND METHODS

A search was conducted in the state of Rio de Janeiro, Brazil, in five distinct locations, involving both formal and informal trade in botanical material, to obtain fresh and dried samples, as presented in the [Table](#).

Table. Fresh, dried, and crushed samples of botanical material collected from five different locations in various municipalities of the state of Rio de Janeiro, Brazil

Samples	Conservation status of samples	Establishment	Municipality
1	Fresh sample	Informal market	Duque de Caxias*
2	Fresh sample	Informal market	Duque de Caxias*
3	Fresh sample	Herb stall	Nilópolis**
4	Fresh sample	Herb stall	Nilópolis**

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Samples	Conservation status of samples	Establishment	Municipality
5	Dried and crushed sample	Supply Center S/A (CEASA)	Irajá neighborhood – Rio de Janeiro city***
6	Fresh sample	Mercadão de Madureira	Madureira neighborhood – Rio de Janeiro city****
7	Fresh sample	Pavuna street market	Pavuna neighborhood – Rio de Janeiro city*****

Located on Prefeito José Carlos Lacerda Street and Deputado Ampliato Cabral Street, city of Duque de Caxias; ** Area popularly known as the “pedestrian walkway” of Getúlio de Moura Avenue, city of Nilópolis; *** Located at Brasil Avenue, 19001, in the Irajá neighborhood, city of Rio de Janeiro, RJ; **** Located on Ministro Edgard Romero Avenue, in the Madureira neighborhood, city of Rio de Janeiro, RJ; ***** Located on Abdala Nádia Street in the Pavuna neighborhood, city of Rio de Janeiro, RJ

Flowering branches of the collected specimens were pressed and subjected to drying in an oven at 50 °C for 24-48 hours in the microscopy laboratory of the Federal Institute of Rio de Janeiro (IFRJ), in the Nilópolis campus. The samples collected in Nilópolis and Duque de Caxias (Table) were taken to the Herbarium (RFA) of the Department of Botany of the Federal University of Rio de Janeiro (UFRJ), where exsiccates were prepared that were later deposited under registration numbers 46327 and 46328.

To identify the collected materials, morphological analyses were conducted on leaves, flowers, stems, and inflorescence types using an ABM-100 stereoscopic microscope with 20X and 40X objective lenses. The observed characteristics were compared with the information described in the specialized literature, including keys for the identification of genera and species of the Asteraceae family⁶⁻¹¹.

For histological analysis, the dried material was rehydrated in a glycerin-water solution (1:1) at 100 °C for approximately 30 minutes. Subsequently, the material was manually sectioned with the aid of a Ranvier microtome (American Optical®) in the transverse plane. The leaves were also subjected to the clearing process to observe the different faces of the epidermis in the paradermic plane, as described by Kraus & Arduin¹².

In the later stage, the material was washed in distilled water and then stained in 1% aqueous safranin for 10 minutes. Next, semi-permanent slides were prepared using 50% glycerin as the mounting medium¹². The slides were analyzed under a light trinocular microscope (Alltion model ABM 103) to observe the characteristics of the leaf epidermis. Photomicrographs were made using a digital camera attached to the mentioned microscope. The results obtained were compared with data available in the specialized literature, as shown below.

RESULTS

After obtaining the samples, the specimens underwent morphological analysis to verify their botanical identity. It was observed that all samples had distinct characteristics from *H. perforatum*. For comparison purposes and to better support the identification, the most important morphological characteristics of *H. perforatum* have been compiled in the discussion.

All the analyzed samples showed an herbaceous growth habit. The root of each of the six analyzed specimens (samples 1 to 6) is always pivotal, with lateral branches originating from the main

root and are yellowish-brown in color. The stem is cylindrical, flexible, and hairy (with trichomes). The leaves are petiolate, simple, oval, with pointed tips, attenuated bases, serrated margins, and with opposite phyllotaxis.

The tiny inflorescences are capitulum-type, typical of the Asteraceae family, in which each capitulum is surrounded by green bracts containing numerous flowers, whose calyx is replaced by hairs and the corolla is tubular, purple or lilac in color. The species produces dry achene-type fruits⁸⁻¹⁰. The set of characteristics presented allowed us to conclude that five of the collected fresh samples (in Duque de Caxias city and in Nilópolis city), at the Madureira market and at the Pavuna fair (both in the city of Rio de Janeiro) did not correspond to *H. perforatum* but rather to *Ageratum conyzoides* L. (Asteraceae) (**Figures A-D**). This species is popularly known as mentrasto and, in other places, as Saint John's wort. However, at different collection sites, they are being sold freely with the popular name "hypericum". The CEASA sample (sample 5) was found to be dried and crushed. To confirm its botanical identity, it was necessary to use a combined analysis of microscopic and macroscopic characteristics.

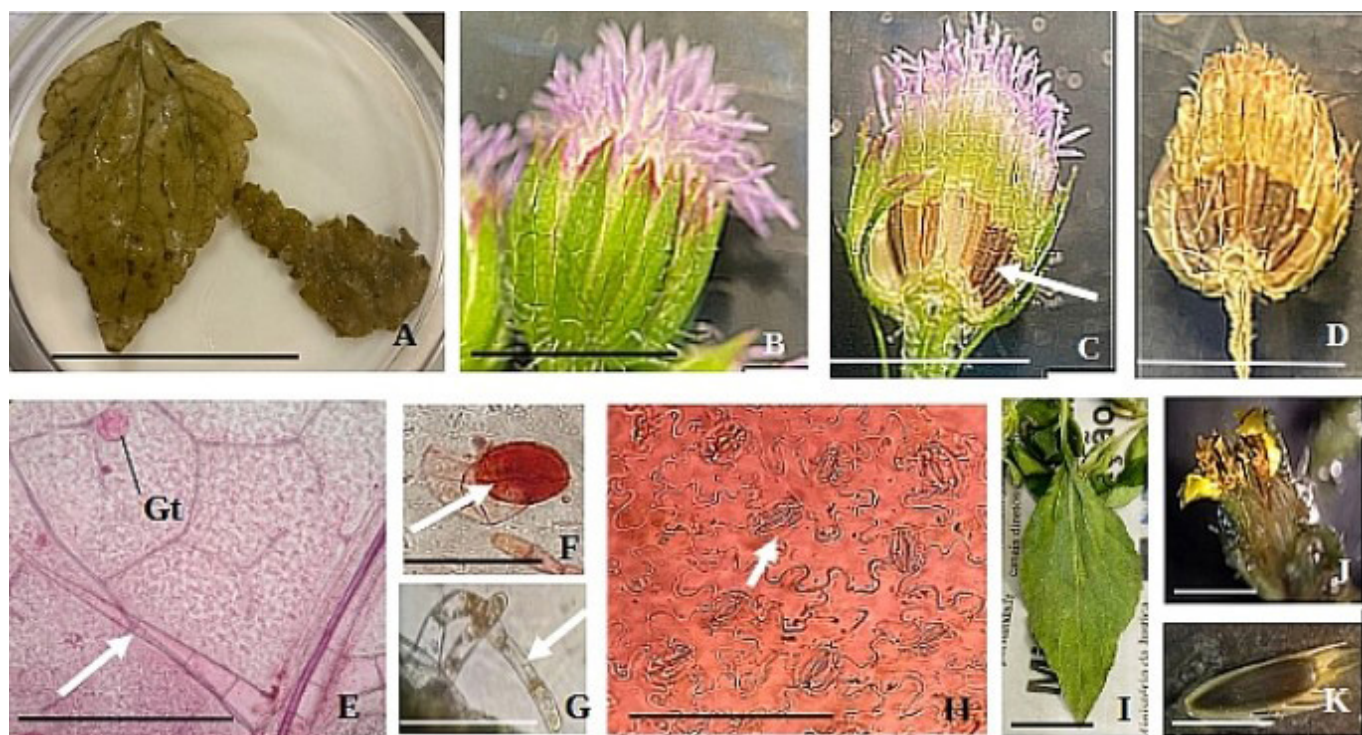


Figure. Macro and micromorphological aspects of samples sold as hypericum. **A-H:** *Ageratum conyzoides* L. **A:** Appearance of an intact leaf (to the left) and another leaf fragment (to the right) from a sample obtained in Duque de Caxias city. Scale bar: 3 cm. **B:** Details of a closed inflorescence and another one sectioned longitudinally, showing its flowers (arrow) in (C), found in six of the analyzed samples. **D:** Dissected inflorescence, in detail, found in a dried sample, obtained in Duque de Caxias city. Scale bar: 5 mm. **E:** Non-glandular uniseriate trichome (arrow), above a vein, and detail of the secretory head of a glandular trichome (Gt), in the paradermic plane of the leaf. **F:** Glandular trichome viewed in detail, in paradermic plane (arrow), in a dried and crushed sample. Scale bars: 100 µm. **G:** Detail of the leaf surface, showing another non-glandular trichome type, in transversal view (arrow). **H:** Anomocytic stomata in detail (arrow). Scale bars: 100 µm. **I-K:** *Synedrella nodiflora*. **I:** Leaf in detail of a sample sold in Nilópolis, RJ. **J:** An inflorescence in detail. **K:** Dissected achene in detail, in the same sample. Scale bars: 1 cm

Source: Prepared by the authors

Regarding the histological features, glandular trichomes, classified by other authors⁸ as capitate type, were observed mainly on the ventral surface of the leaf epidermis and between veins, as well as two different types of uniseriate trichomes, classified as non-glandular. The trichomes are predominantly located on the leaf margin and on the leaf veins, with very characteristic shapes on the leaves and also on the stem, although in smaller quantities, as can be seen in **Figures E-G**. The set of diagnostic features is completed by the presence of anomocytic stomata on the adaxial and abaxial surfaces of the leaf (**Figure H**).

The set of characteristics presented led us to conclude that this dry and crushed sample also corresponds to *Ageratum conyzoides* L. (Asteraceae).

The seventh sample, also obtained from the popular market in the city of Nilópolis, revealed an herbaceous habit, with simple, petiolate leaves sometimes serrated at the edges, with inflorescences formed by capitulum. The female flowers occupy the periphery of the inflorescence and have a ligulate corolla that is yellowish, while those in the center of the capitulum are hermaphroditic and yellow. The fruits are heteromorphic achenes, with those from the ray having winged and serrated edges, and those from the disk being triquetous, with an aristate pappus^{9,11}. These characteristics allowed it to be identified as *Synedrella nodiflora* (L.) Gaertn. (Asteraceae) (**Figures I-K**).

In summary, the results from all samples analyzed and marketed as hypericum or St. John's wort, based on morphological and histological analyses, revealed distinct characteristics from *H. perforatum*. They belong to *A. conyzoides* and *S. nodiflora* species.

DISCUSSION

H. Perforatum is an herbaceous species with an average height of 50 cm, reaching up to about 100 cm. It has a straight, rounded stem with two prominent longitudinal lines and branches at the top.

There are several branches whose growth changes direction multiple times. The root has a woody, resilient appearance from the seedling stage. Its color is yellowish-brown, and its surface is covered with rings that have scales.

The stem may contain elongated black glands. The leaves are elongated, elliptical or oval, with smooth edges, measuring 7 to 40 mm in length, subcordate, flat or moderately revolute, and bearing numerous transparent glands or oil glands that secrete oil, forming a colorless layer over the leaves. Their texture and surface are elastic, bluish-green, dull and without shine, without a petiole and with opposite phyllotaxy. The flowers are numerous, pentamerous, golden-yellow-orange petals in color, arranged in clusters, in a cyme-like or corymbiform inflorescences. The calyx and corolla are marked with black spots. The petals are oblong to elliptical and asymmetrical. The seeds are small, elongated, and with rounded ends⁶⁻⁹.

The substitution of *H. perforatum*, even when unintentional, has significant pharmacological implications in patient treatment. *H. perforatum* contains hypericin and hyperforin – compounds responsible for its antidepressant effects through modulation of monoamine neurotransmitters, whereas *A. conyzoides* and *S. nodiflora* present distinct chemical profiles and pharmacological activities, such as anti-inflammatory and antimicrobial effects^{6,8,11}. Consequently, consumers seeking herbal therapy for depression may receive products lacking the expected therapeutic efficacy and, in some cases, potentially

harmful due to hepatotoxic or allergenic constituents. Therefore, the correct identification of the plant species is so important.

These findings align with previous studies documenting the adulteration or misidentification of medicinal species in public markets and informal trade environments. Inadequate labeling, lack of traceability, and the absence of professional supervision during plant collection and commercialization contribute to the persistence of this issue. Additionally, small-scale vendors often rely on vernacular names that vary regionally and may refer to distinct taxa¹³.

From a sanitary and public health perspective, the sale of adulterated plant material poses risks to consumers who often assume that “natural products” are inherently safe¹⁴. The results of this research highlight the urgent need to implement health surveillance programs to inspect herbs in formal and informal markets. Furthermore, partnerships among universities, regulatory agencies (such as National Health Surveillance Agency Anvisa), and local communities could enhance the traceability and authentication of marketed products. It's worth noting that, according to the (Anvisa) in Brazil, under Normative Instruction number 410 of Dec 17th, 2025, *A. conyzoides* is subject to restrictions and may be used externally and on intact skin¹⁵. This fact is related to the presence of alkaloids with hepatotoxic effects and can represent a real risk to consumer health.

Histological and anatomical characteristics can be very useful for identifying plant raw materials, especially in leaf anatomy, as they allow verification of botanical authenticity, even when the material is fragmented or powdered⁵.

In this paper, it is important to highlight that trichomes and stomata are important diagnostic features, particularly for confirming the identification of *A. conyzoides*. In this case, the capitate glandular trichome and the two types of non-glandular trichomes, together with the presence of stomata, classified in this work as anomocytic, complete this set of diagnostic characteristics.

Regarding *A. conyzoides*, there is disagreement about the types of stomata found. Some studies are unanimous in classifying stomata as anomocytic, but other authors also mention the occurrence of anisocytic and even brachyparacytic stomata. In the present paper, we will be more conservative, based on observations in the materials obtained, and classify these stomata only as anomocytic⁸.

The obtained results provided valuable evidence of misidentification and adulteration patterns in Rio de Janeiro, reinforcing the importance of expanding similar botanical screening efforts to other regions of this state. Future investigations should also integrate chemical analyses not only to confirm the botanical identity of species, but also to verify the presence of chemical markers and quantify any contaminants or adulterants in different types of herbal preparations.

CONCLUSION

The identification of the botanical material commonly marketed as St. John's wort (samples 1-7) allowed us to conclude that:

- Six samples corresponded to the species *Ageratum conyzoides* and one sample corresponded to *Synedrella nodiflora*. This substitution of plant species, even if unintentional, may pose a risk to the health of the consuming public;

- As perspectives for the continuity of the present work aim to increase the number of samples analyzed, including those from other cities in the Rio de Janeiro state that have not yet been visited, to gain a better understanding of the commercial quality of these medicinal plants, comparing the results eventually obtained with those presented in this study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding this manuscript.

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AUTHOR'S CONTRIBUTIONS

Ariele Freire da Silva: analysis and interpretation of results, drafting and critical revision of the manuscript content. Carlos Alexandre Marques: conception and design of the study, analysis and interpretation of results, drafting and critical revision of the manuscript content. All authors approved the final version and assume public responsibility for the content of the work.

PRESENTATION NOTE

The authors declare that the manuscript is based on the academic work titled “Review and evaluation of medicinal plants with antidepressant activity sold in the informal market,” submitted in 2023 to the Federal Institute of Education, Science and Technology of Rio de Janeiro (IFRJ) to obtaining the Bachelor's degree in Chemistry (Ariele Freire da Silva); the work was supported by the PIBIC/PROPPI, undergraduate research program funded by IFRJ (Call for Proposals No. 01/2020).

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