

Is peperina (*Minthostachys verticillata*) exclusively found in South America?

NELIDA LUCIA DEL MASTRO

Center of Radiation Technology, Institute for Energy and Nuclear Researches (IPEN/CNEN), Av Prof Lineu Prestes 2242, 05508-900, Sao Paulo, SP, BRAZIL

Abstract: Medicinal plants are used since prehistoric times all around the world, particularly among native people of South America. In the present work several scientific studies are quoted that described the use of *Minthostachys verticillata*, or *M. mollis* (*Lamiaceae*) commonly referred to as “peperina”, a medicinal native plant, with various uses and properties, considered for many native to Argentina Northeast. Same common names can be used in different places for diverse plants, then we consider that it is not rare the appearance of misunderstanding, using the common name “peperina” meaning different plants. For that reason, the question stated at the title of this article: Is peperina (*Minthostachys verticillata*) exclusively found in South America?” remains without a proper and unambiguous answer worldwide.

KeyWords: Genus *Mentha*, peperina, *Minthostachys verticillata*, *Myinthostachys mollis*, *Lamiaceae*, plant natural products, systematic classification.

Received: October 26, 2022. Revised: May 22, 2023. Accepted: June 22, 2023. Published: July 18, 2023.

1. Introduction

Natural products, mainly from plants, are employed by humans from the beginnings of time [1]. The World Health Organization established guidelines for methodologies on research and evaluation of traditional medicine in 2000 and complemented with traditional medicine strategies since then [2-4].

In Argentina, according to Barboza et al (2009) native medicinal flora includes several members of the families *Verbenaceae*, *Lamiaceae* and *Myrtaceae* rich in essential oils, effective against viruses, bacteria, fungi, trypanosomes, mites, nematodes, head lice, with analgesic, antioxidant, anti-diarrheic, spasmolytic, hepatotoxic, choleretic, antispasmodic, anti-inflammatory, cytoprotective, anti-allergic, and lymphoproliferative activity [5].

Based on the published scientific literature, we will start describing what “peperina” (*Minthostachys verticillata*) is, what is used for and why we consider that due to the employ of common names in different places lead to make a confusion on the real endemism of this plant. Due to varying views, the species is sometimes subsumed with others under the name *Minthostachys mollis* Griseb. Nowadays, peperina is defined in the Flora of Argentina as *Minthostachys mollis* Griseb. [6-7] in agreement with Epling and Jativa [8]. Nevertheless, most references still quote peperina as *Minthostachys verticillata* (Griseb.) Epling, being the quality of its essential oil standardized as described in the Argentine Institute of Standardization and Certification - IRAM norms [9].

2. Results and Discussion

2.1 Definitions and Components

Binomial Name: *Minthostachys verticillata* (Griseb.) Epling

Family: *Lamiaceae* Genus *Minthostachys* Species: *M. verticillata*

Minthostachys is a genus of the mint family *Lamiaceae*.

It occurs along the Andes from Northern Venezuela through Colombia, Ecuador, Peru and Bolivia to Central Argentina [10]. The exact distinction between species is unclear; it is estimated that 13 to 24 species exist. Hybridization occurs naturally where some species' ranges overlap. Many hybrids and cultivars are known.

The *Lamiaceae*, according to wikipedia (<https://en.wikipedia.org/wiki/Lamiaceae>) are a family of flowering plants commonly known as the mint family. The plants are commonly aromatic in all parts and include culinary herbs, such as basil, mint, rosemary, sage, oregano, thyme, hyssop and medicinal herbs such as catnip, salvia, bee balm. Some species are shrubs, trees or, rarely, vines. Many members of the family are widely cultivated, not only for their aromatic qualities, but also for their ease of cultivation, since they are readily propagated by stem cutting [11,12]. Besides those grown for their edible leaves, some are grown for decorative foliage. Others are grown for seed, such as *Salvia hispanica* (chia) and *Stachys affinis* (Chinese artichoke).

The genus *Mentha* (mint) of the botanical family *Lamiaceae* includes various plants, cultivated or wild, that, due to the frequent hybridization between species, the

high phenotypic plasticity and genetic variability, is a genus taxonomically complex, with more than 3000 names published since 1753, in his most synonyms or denominations still unresolved. Although in the bibliography there is no consensus for an unequivocal systematic classification, a review, by Salehi et al., (2018) based on morphological, cytological and genetic characteristics allow it to be divided into 42 species, 15 hybrids and hundreds of subspecies, varieties and cultivars distributed in the five continents [13].

In 2004 Harley *et al.* had reported that the enlarged *Lamiaceae* contained about 236 genera. Mint, (genus *Mentha*), was the genus of 25 species of the mint family (*Lamiaceae*) [14]. Mint is considered as native to Eurasia, North America, southern Africa, and Australia; are distributed around temperate areas of the world and have become naturalized in many places. Some species, such as peppermint and spearmint, are employed as flavorings for foods (including candy and gum) and for liqueur and dentifrices. The essential oils of mints are used in perfumery and also in herbal medicine (<https://www.britannica.com/plant/Mentha>).

Latifian & Arslanoğlu [15] described in particular *Mentha longifolia*, the mint known locally as “nane” (*Mentha longifolia* L.) is a plant of *Lamiaceae* of Eurasian and Australian origin. Piperide oxide, piperitone, piperitenone, pulegone, d-limonene, carvone, mentone, β -caryophyllene, 1,8-cineol and menthol can be named from the herbal compositions found in this plant. This perennial plant can be as long as 0.5 - 1 m. It proliferates in the warm and dry climate. The pleasant smell-leaves, are one of the most consumed medical plants of East Azerbaijan.

Minthostachys (Benth.) Spach was first described and published in Hist. Nat. Vég. 9: 164 (1840) as an accepted genus, being the native range of this genus South Tropical America, family *Lamiaceae*. The genus *Minthostachys* Griseb. (*Lamiaceae*) is found in middle elevations along the Andes, from Venezuela to Argentina [16].

Minthostachys verticillata (Griseb.) Epling, first published in: Repert. Spec. Nov. Regni Veg. Beih. 85: 167 (1936), source: The World Checklist of Vascular Plants (WCVP) (<https://www.gbif.org/species/3884472>), is a climbing shrub and grows primarily in the subtropical biome (<https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:1203793-2>)

M. verticillata (Griseb.) Epling.

The Biodiversity Information System of the National Parks Administration of Argentina (*Sistema de Información de Biodiversidad de la Administración de Parques Nacionales*, Argentina)

(<https://sib.gob.ar/especies/minthostachys-verticillata#presencia-title>) classified *Minthostachys verticillata* as: Plantae / Magnoliophyta / Magnoliopsida / Lamiales / Lamiaceae / *Minthostachys/Verticillata*; common name in Spanish: “Peperina”, Author: (Griseb.)

Epling. In that register, the origin: Autochthonous, Argentina.

The peperina (*M. verticillata*) is an ethnobotanical aromatic herb, plant height: 0.3 to 2 m, with various uses and properties. Montiróni et al. [17] considered that it is native to Argentina Northeast, Argentina Northwest, although the *Lamiaceae* family had a cosmopolitan distribution. This species grows primarily in the subtropical biome (<https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:1203793-2>).

The species *M. verticillata* is distributed in South American countries such as Colombia, Venezuela, Brazil, Ecuador, Peru, Bolivia, and in the northwest and central regions of Argentina [18]; it is known as peperina, being the only species of the genus *Minthostachys* known from Argentina, where it is found in the provinces of Catamarca, Córdoba, La Rioja, San Luis, Tucumán, eco regions: Aconquija, Altos Andes and Selva de Yungas (<https://faunayfloradelargentinanativa.blogspot.com/2017/09/peperina-minthostachys-verticillata.html>).

According to Fondazione Slow Food (<https://www.fondazione Slow Food.com/it/arca-del-gusto-slow-food/menta-peperina>), peperina (*Minthostachys verticillata*) is an aromatic wild plant, widespread in central and northwestern Argentina, in the hilly areas and in the “sierra” between the provinces of Córdoba and San Luis. The soft and round leaves release a scent of mint, camphor and rosemary; they are highly appreciated and used in the preparation of infusions and in particular the dry leaves are added to the famous mate.

Ojeda et al. [19] reported the variability in natural populations of peperina (*Minthostachys mollis* (Kunth.) Griseb. Glinos et al. [20]. They considered the key socio-cultural role of *Minthostachys* species and evaluated their reproductive requirements as part of their conservation. They established that *M. verticillata* is a gynodioecious species endemic from Argentina. They consider that their populations are threatened because due to overexploitation and habitat loss, and are dependent on animal pollination for seed production being visited by a assemblage of insects (*Diptera*, *Lepidoptera* and *Hymenoptera*), being the tachinid fly *Ptilodexia* cf. *cingulipes* the main pollinator. Ojeda et al. [21] reported that the yield of peperina (*Minthostachys mollis* (Kunth.) Griseb.) populations is dependent on the cropping regimen.

Bonafede et al. [22] studied the genetic variability among *Minthostachys verticillata* populations collected in the central and northwest region of Argentina and found huge values of it.

Essential oils (EO) are plant derivatives usually formed by few compounds as main constituents added with some minority compounds. EO make a chemotype profile of the plant and play a leading role in numerous ecological interactions [23]. *M. verticillata* EO are synthesized and stored in some anatomical structures named glandular

trichomes, which are developed mainly in leaves and inflorescences [24]. Peperina (*M. verticillata*) may be the most economically important species of its genus, as it is collected extensively for its essential oils [25-27]. Both extracts and essential oils display a broad spectrum of activity, closely related to its phytochemical composition. Zygadlo et al. [26] analyzed, by gas chromatography (GC) and GC/mass spectroscopy (GC/MS) the composition of *M. verticillata* EO and corroborated the great variability among populations in Argentina, results found already by others.

De Feo et al. [28] had studied the chemical composition of *M. verticillata* oil from Argentina and had identified, by (GC) and (GC/MS), forty-five compounds, accounting for 94.2% of the oil, characterized by mono-terpenes (91.6%), of which 73.6% were oxygenated compounds. They also found that pulegone (37.8%) and menthone (29.2%) were the main constituents.

Elechosa et al. [29] made a comparative study of the *M. mollis* EO from collections in 21 populations of the provinces of Tucumán, Córdoba, San Luis and Catamarca in Argentina

They found that the EO yields were highly variable (0.25-4.93%), standing out the values obtained in the populations of the province of Córdoba (Ambul- 4.20%) and San Luis (Merlo- 4.93%), while those of Tucumán and Catamarca were generally less than 1%. As for the composition, the 5 collections from Córdoba respond to the type menthone (23.8-52.6%)- pulegone (38.6-49.2%); those of San Luis to the pulegone type (52.0-76.5%)- menthone (13.2-39.1%). The 12 collections from Tucumán respond to various chemotypes. The possible existence of about 10 chemotypes was detected. The collections of Córdoba belong to the traditional (menthone- pulegone), while in San Luis the pulegone predominates over the menthone. Other works corroborated the qualitative chemical composition. According to a study by Cariddi et al. [30], also pulegone (51.7%) and menthone (37.8%) made up the main compounds in *M. verticillata* oil, along with 1.4% of cismenthone and 1.4% of piperitone.

Sanchez-Tito [31] found also that main compounds found in *M. mollis* were menthone (32.9%) and eucalyptol (28.1%). It is important to mention, that eucalyptol is also known by a variety of synonyms: 1,8-cineol, limonene oxide, cajepitol, 1,8-epoxy-p-menthane, 1,8-oxido-p-menthane, eucalyptol, eucalyptole, 1,3,3-trimethyl-2-oxabicyclo [2,2,2] octane, cineol, cineole. repeatedly found in aromatic species growing in Northwestern Argentina.

Ocaño [32] used wild populations of *Minthostachys verticillata* (Griseb.) Epling “peperina” as a first source for plant breeding along with the selection of individuals derived from pre-existing Champaqui-FCA cultivar. He obtained a broad genetic base population of peperina.

Bonafede et al. [33] studied also the genetic variability among *Minthostachys verticillata* populations collected in

the central and northwest region of Argentina using a total of 93 plants from nine locations. The chemical biodiversity of *Minthostachys mollis* in Argentina was also corroborated by Van Baren et al.

Due to the extensive use as a medicine by local people, like many other indigenous plants that grow on the heights of the Argentine sierras, peperina is at risk due to unsustainable harvesting methods. Heavy or continued exploitation of *Minthostachys verticillata* in Córdoba, Argentina, mainly in the areas of the valleys of Calamuchita, Punilla and the valley of Translasierra, risks the regeneration of the natural sourced population. The consumption and use for the preparation of infusions, together with the commercial boom of products based on this or other wild plants, have led to an overexploitation which today is increasingly difficult to find on the Argentine hills. Sometimes the principal threat to medicinal species is not over-harvesting but the destruction and conversion of their habitats to other purposes.

As the peperina from the province of Córdoba is in danger of extinction, in 2019 some local legislators sought to save it through a provincial project to declare it a “provincial flower”, to train those who work in harvesting and protect the wild crop. In Córdoba, it is cultivated mainly in the areas of the valleys of Calamuchita, Punilla and the valley of Translasierra.

The preservation of species in the native flora is of huge importance and crucial for the maintenance of biodiversity [34,35].

2.2 Peperina as a Medicinal Plant

It is well known that several members of the families *Verbenaceae*, *Lamiaceae* and *Myrtaceae*, are rich in essential oils and have their native range South Tropical America.

Peperina, being classified as *M. verticillata* or *M. mollis*, is used in traditional medicine for the treatment of very different ailments. Just for mention ones, it is employed as antidiarrheic, digestive, sedative, antispasmodic, along with to treat respiratory ailments such as asthma and bronchitis, to alleviate rheumatic pains, headache, heart palpitations and anemia [36]. Basso et al. [37] validated the folk use of *M. verticillata* for several of those mentioned ailments.

Monoterpenes, as mentioned already, are the primary components of EO herbs like *M. verticillata* or *M. mollis*, and often in combination with sesquiterpenes (C15) and diterpenes (C20) exhibit important antimicrobial actions. Extracts of the genus mint are commonly used as foods and appreciated by their significant amounts of antioxidant phenolic compounds. Studies in vitro were published showing the antiviral, immunomodulator, antibacterial and antifungal properties of *M. verticillata* EO [38-42].

A study of 2006 by Sutil et al. [43], had revealed that *M. verticillata* EO does not induce early or severe damage on Vero cells and the analysis of cytotoxicity on *A. salina* showed that the EO was much less toxic than the isolated constituents. So far, *M. verticillata* EO has proven to be safe presenting no toxicity in different experimental systems [44,45]. Rashed et al. [46] published in 2021 an article highlighted the conventional and nonconventional approaches about the properties of essential oils and their compounds for application in skin fungal infections. Good updates of the role of EO and plant extracts as new approaches for the treatment for bacterial mastitis in dairy cattle were publishing recently [47,48].

2.3 Use of Latin Names and Common Names

Latin names are the usual way to express the proper name of plants. In principle, they are unambiguous. A Latin name refers to only one species. At any time a species has only one official Latin name, but other names still exist in older texts. In ordinary language, a species may have different names in different places, and different species may be known by the same name [49,50]. Trying to overcome that, in the United State of America, the American Herbal Product Association's book *Herbs of Commerce*, 2nd ed. McGuffin et al. [51] make available an extensive list of marketed species and specifies for each the preferred common name. A question arrives about scientific or commercial communication among people who speak different languages, or that there are a lot of foreign plants that have no common names in English.

Most hybrid plants are not given formal names, but are described by their parentage. Besides the taxonomical richness of the native medicinal flora, no always is possible to determine endemism areas of the medicinal flora. Scandaliaris, Fuentes & Lovey [52] made a publication on the individualization of "peperina", *Minthostachys mollis* (Kunth) Griseb. (Lamiaceae). They reported that has been introduced for its commercialization in the nursery market in Argentina, in Córdoba in particular, and marketed under the same vernacular name, an "exotic peperina" is, *Calamintha nepeta* (L.) Savi subsp. *nepeta* (Lamiaceae), herbaceous perennial, native to the Mediterranean basin. These aroma-like plants share chemical compounds such as menthol, pulegone, and piperitone, but differ in their morphological characters. Those authors highlight the importance of the vegetative and reproductive characters for the recognition and individualization of both species.

3. Conclusion

In the bibliography there is no consensus for an unequivocal systematic classification of mint genus. Native medicinal flora has such a taxonomical richness that

no always it is possible to determine properly endemism areas of the medicinal flora. *Minthostachys verticillata* (Griseb.) Epling is native to South America, mainly Argentina Northeast, Argentina Northwest (<https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:1203793-2>). But the Royal Botanic Garden (<https://mpns.science.kew.org/mpns-ofportal/searchName?searchTerm=peperina&nameType=all>) registered that the term "Peperina", has an Accepted Scientific Name of *Minthostachys verticillata* with a much smaller frequency of appearance in medicinal sources, when compared to *Mentha x piperita* L. (2/58). On the other hand, Montironi et al. mentioned in 2022 that the plant *Minthostachys verticillata* (Griseb.) Epling (Lamiaceae), commonly known as "peperina" exists in east Azerbaijan as well as in South American countries such as Brazil, Venezuela, Bolivia, Ecuador, and Argentina's northwest and central regions. As a source of that statement, they referred to Latifian and Arslanoglu that in 2018 published an article where is described just *Mentha longifolia*, the mint known locally as "nane" (*Mentha longifolia* L.) a plant of Lamiaceae of Eurasian and Australian origin. From the exposed above, is not possible categorically to give an answer to the question raised on the title of this article. As was already described, "peperina" grows easily so it is possible to be carry on from one place to another to grow or, mislead *Minthostachys verticillata* with another Lamiaceae such as *Mentha longifolia* L. or the hybrid *Mentha x piperita* L.

References

- [1]. Shi QW, Li LG, Huo CH, Zhang ML, Wang YF. Study on natural medicinal chemistry and new drug development. Chin. Tradit. Herb. Drugs. 2010; 41:1583-1589.
- [2]. World Health Organization. General guidelines for methodologies on research and evaluation of traditional medicine. 2000; Geneva: WHO.
- [3]. World Health Organization WHO traditional medicine strategy: 2002-2005; 2002; Geneva: WHO.
- [4]. World Health Organization. WHO traditional medicine strategy: 2014-2023.; 2014; Geneva: WHO.
- [5]. Barboza G., Cantero JJ, Núñez C, Pacciaroni A, Ariza Espinar L. Medicinal Plants: A general review and a phytochemical and ethnopharmacological screening of the native Argentine Flora. Kurtziana. 2009; 34(1-2): 7-365.
- [6]. Zuloaga FO, Morrone O, Belgrano MJ. Catálogo de las Plantas Vasculares del Cono Sur (Argentina, Sur de Brasil, Chile, Paraguay y Uruguay). Catálogo de las Plantas Vasculares del Cono Sur (Argentina, Sur de Brasil, Chile, Paraguay y Uruguay). 2008; 3.
- [7]. Van Baren CM, Lira PDL, Elechosa MA, Molina AM, Juarez MA, Martinez A, Perelman S, Bandoni AL. New insights into the chemical biodiversity of

- Minthostachys mollis* in Argentina. *Biochemical Systematics and Ecology*. 2014; 57:374-383.
- [8]. Epling CC, Jativa C. Supplementary notes on American Labiatae VIII. *Brittonia*. 1963; 15:366-376.
- [9]. IRAM Argentine Institute of Standardization and Certification. IRAM. 2003. Flavoring products. Essential oils. Determination of the content of volatile oils. IRAM 18606 standard. IRAM- Instituto Argentino de Normalización y Certificación 18606, 2003. Productos aromatizantes. Aceites esenciales. Aceite de peperina, tipo Argentino [*Minthostachys mollis* (Kunth) Griseb.]] (In Spanish).
- [10]. Schmidt-Lebuhn AN. Las especies Bolivianas de *Minthostachys* (Lamiaceae). *Revista de la Sociedad Boliviana de Botánica*. 2009; 4:225-244.
- [11]. Ojeda M, Arroyo A, Borgogno P, Biderbost E, Balzarini M. Evaluation of variability in natural populations of peperina (*Minthostachys mollis* (Kunth.) Griseb.), an aromatic species from Argentina. *Plant Genet Resour Newsl*. 2004;126: 27-30.
- [12]. Bima P, Vargas L, Ojeda M. In vitro propagation of peperina (*Minthostachys mollis* (Kunth.) Griseb.). *Mol Med Chem*. 2006;11:3-5.
- [13]. Salehi B, Stojanović-Radić Z, Matejić J, Sharopov F, Antolak H, Kręgiel D, Sen S, Sharifi-Rad M, Acharya K, Sharifi-Rad R, Martorell M, Sureda A, Martins N, SharifiRad J. Plants of Genus *Mentha*: From Farm to Food Factory. *Plants* (Bassel). 2018; 7:7-36.
- [14]. Harley RM, Atkins S, Budantsev AL, Cantino PD, Conn BJ, Grayer RJ, Harley MM, K R, Krestovskaia T, Morales R, Paton AJ, Ryding O, Upton T. "Labiatae" p. 167-275. In: Klaus Kubitzki (editor) and Joachim W. Kadereit (volume editor). *The Families and Genera of Vascular Plants*. 2004; VII. Springer-Verlag: Berlin; Heidelberg, Germany. ISBN 978-3-540-40593-1
- [15]. Latifian E, Arslanoğlu ŞF. Traditional Medicinal Plants of Azerbaijan Province of Iran. *Agricultural Sciences*. 2018; 9:157-170. <https://doi.org/10.4236/as.2018.91012>
- [16]. Alkire BH, Tucker O., Maciarello MJ. Tipo *Minthostachys mollis* (Lamiaceae): an ecuatorial mint. *Econ. Bot*. 1994; 48:60-64.
- [17]. Montironi ID, Cariddi LN, Reinoso EB. Evaluation of the antimicrobial efficacy of *Minthostachys verticillata* essential oil and limonene against *Streptococcus uberis* strains isolated from bovine mastitis. *Revista Argentina de Microbiología*. 2016; 48(3):210-216.
- [18]. Montironi ID, Campa N, Arsaut S, Cecchini ME, Raviolo JM, Vanden Braber N, Barrios B, Montenegro M, Correa S, Grosso MC, Mañas F, Bellingeri RV, Cariddi LN. *Minthostachys verticillata* Griseb (Epling.) (Lamiaceae) essential oil orally administered modulates gastrointestinal immunological and oxidative parameters in mice. *J Ethnopharmacol*. 2022; 290:115078. doi: 10.1016/j.jep.2022.115078. Epub 2022 Feb 11. PMID: 35157954.
- [19]. Ojeda M, Coirini R, Cosiansi J, Zapata R, Zygadlo J. 2001. Evaluation of variability in natural populations of peperina (*Minthostachys mollis* (Kunth.) Griseb.), an aromatic species from Argentina. *Plant Genet Resour Newsl*. 2001;126: 27-30.
- [20]. Ojeda M.; Arroyo A, Borgogno P, Biderbost E, Balzarini M. Yield of peperina (*Minthostachys mollis* (Kunth.) Griseb.) populations in the year following planting: Response to cropping regimen. *Spanish Journal of Agricultural Research*. 2004; 2(3):393. DOI: 10.5424/sjar/2004023-94.
- [21]. Glinos E, Condat E, Mulieri P, Ashworth L. Essential dependence on wild pollination service: a medicinal plant under threat *Minthostachys verticillata* (Lamiaceae). *Arthropod-Plant Interactions*. 2019; 13:865–874. <https://doi.org/10.1007/s11829-019-09705-z>.
- [22]. Bonafede M, Marsal V, Arteaga M. Diversity distribution analysis in *Minthostachys verticillata* Epling (Griseb) (Lamiaceae) (peperina) populations by EST- SSR markersnet. *Journal of Biodiversity and Environmental Sciences (JBES)*. 2014; (Online) 5(60), 190-199. <http://www.innspub.net> ISSN: 2220-6663 (Print) 2222-3045
- [23]. Lambers H, Chapin, FS, Pons TL. Ecological biochemistry: allelopathy and defense against herbivores. Springer New York. In *Plant Physiological Ecology*. 2008; 445-477.
- [24]. Arteaga M, Collado, C, Gil A. Characterization of glandular trichomes of *Minthostachys verticillata* "peperina" from northwest and Central Argentina: relation with essential oil content. *J Biodiversity Enviroment Sci*. 2016; 8:172–181.
- [25]. Lizzi SM, Retamar JA. Aceite esencial de *Minthostachys verticillata* (Griseb.) Epling. *Rivista Italiana Essenze, Profumi, Piante Officinali, Aromi, Saponi, Cosmetici, Aerosol*. 1975; 57: 219–220.
- [26]. Zygadlo JA, Maestri DM, Lamarque AL, Guzman CA, Velasco-Negueruela A, Perez-Alonso MJ, García-Vallejos, MC, Grosso NR. Essential oil variability of *Minthostachys verticillata*. *Biochem. Syst. Ecol*. 1996; 24:319-323, Missouri Botanical Garden Press, Missouri, USA.
- [27]. Primo V, Rovera M, Zanon S, Oliva M, Dem M., Daghero J, Sabini L. Determination of the antibacterial and antiviral activity of the essential oil from *Minthostachys verticillata* (Griseb.) Epling. *Revista Argentina de Microbiología*. 2001; 33(2), 113–117.
- [28]. De Feo V, Ricciardi AI, Biscardi D, Senatore F. Chemical Composition and Antimicrobial Screening of the Essential Oil of *Minthostachys verticillata* (Griseb.) Epl. (Lamiaceae). *J Essential Oil Res*. 1998; 10(1): 61-65. <https://doi.org/10.1080/10412905.1998.9700839>
- [29]. Elechosa M A, Molina A M, Juárez MA, Baren C M. van, Di Leo Lira P, Bandoni AL. Comparative study of the essential oil of *M. mollis* (Kunth.) Griseb "peperina" obtained in collections of 21 populations of the provinces

of Tucumán, Córdoba, San Luis and Catamarca (Estudio Comparativo del aceite esencial de *M. mollis* (Kunth.) Griseb “peperina” obtido de colectas de 21 poblaciones de las provincias de Tucumán, Córdoba, San Luis y Catamarca). *Latin American and Caribbean Bulletin of Medicinal and Aromatic Plants*. 2007; 6(5), 244-245 University of Santiago de Chile Santiago, Chile (In Spanish).

[30]. Cariddi L, Escobar F, Moser M, Panero A, Alaniz F, Zygodlo J, Sabini L, Maldonado A. Monoterpenes isolated from *Minthostachys verticillata* (Griseb.) Epling essential oil modulates immediate-type hypersensitivity responses in vitro and in vivo. *Planta Med*. 2011; 77:1687-1694. <http://dx.doi.org/10.1055/s-0030-1271090> |

[31]. Sánchez-Tito MA, Cartagena-Cutipa R, Flores-Valencia E, Collantes-Díaz I. Chemical composition and antimicrobial activity of essential oil from *Minthostachys mollis* against oral pathogens. *Revista Cubana de Estomatología*. 2021; 58(4) Lilacs-Express | ID: biblio-1408351.

[32]. Ocaño SF. Generation of a population of “peperina” *Minthostachys verticillata* (Griseb.) Epling, improved for health, yield and quality of essential oils. (Generación de una población de “peperina” *Minthostachys verticillata* (Griseb.) Epling, mejorada por sanidad, rendimiento y calidad de aceites esenciales) PhD Thesis, Universidad Nacional de Córdoba, 132p. (In Spanish). 2017.

[33]. Bonafede M, Marsal V, Arteaga M. Diversity distribution analysis in *Minthostachys verticillata* Epling (Griseb) (Lamiaceae) (peperina) populations by ESTSSR markers. *Journal of Biodiversity and Environmental Sciences (JBES)* ISSN: 2220-6663 (Print) 2222-3045 (Online). 2014; 5(6):190-199. <http://www.innspub.net>

[34]. Anonymous. “New Botany Study Findings Have Been Reported from INTA [High-efficiency Direct Somatic Embryogenesis and Plant Regeneration from Leaf Base Explants of ‘peperina’ (*Minthostachys Verticillata*)].” *Life Science Weekly*, 25 Aug. 2020; 2546. Gale Academic OneFile, link.gale.com/apps/doc/A633324485/AONE?u=capes&sid=bookmark-AONE&xid=a84092c7. Accessed 23 Mar. 2023.

[35]. Bertero VG, Beznec A, Faccio P, Auteri M, Arteaga M, Bonafede M, Bossio E. 2020, 2020. High-efficiency direct somatic embryogenesis and plant regeneration from leaf base explants of “peperina” (*Minthostachys verticillata*). *In Vitro Cellular & Developmental Biology - Plant*. 2020; 56:915–919. <https://doi.org/10.1007/s11627-020-10098-5>.

[36]. Schmidt-Lebuhn AN. Ethnobotany, biochemistry and pharmacology of *Minthostachys* (Lamiaceae), *Journal of Ethnopharmacology*. 2008; 118(3), 343-353. ISSN 0378-8741, <https://doi.org/10.1016/j.jep.2008.05.030>.

[37]. Rodríguez Basso A, Carranza A, Zainutti VM, Bach H, & Gorzalczany SB. Pharmacological activity of

peperina (*Minthostachys verticillata*) on gastrointestinal tract. *Journal of ethnopharmacology*. 2021; 269: 113712. <https://doi.org/10.1016/j.jep.2020.113712>

[38]. Demo MS, Oliva MM. Antimicrobial activity of medicinal plants from South America. 2008. Book Chapter. *Botanical Medicine in Clinical Practice*, p. 152-163. <https://doi.org/10.1079/9781845934132.0152>.

[39]. González MJ, Marioli JM. Antibacterial activity of water extracts and essential oils of various aromatic plants against *Paenibacillus larvae*, the causative agent of American Foulbrood. *J Invertebr Pathol*. 2010;104: 209-213. <http://dx.doi.org/10.1016/j.jip.2010.04.005> | Medline

[40]. Cecchini ME, Paoloni C, Campra N, Picco N. et al. Nanoemulsion of *Minthostachys verticillata* essential oil. In-vitro evaluation of its antibacterial activity. *Heliyon*. 2021;7(1), e05896, ISSN 2405-8440, <https://doi.org/10.1016/j.heliyon.2021.e05896>.

[41]. Montironi ID, Reinoso EB, Paullier VC, Siri MI, Pianzola MJ, Moliva M, Campra N, Bagnis G, Ferreira LaRocque-de-Freitas I, Decote-Ricardo D, Freire-de-Lima CG, Raviolo JM, & Cariddi LN. *Minthostachys verticillata* essential oil activates macrophage phagocytosis and modulates the innate immune response in a murine model of *Enterococcus faecium* mastitis. *Research in Veterinary Science*. 2019; 125:333-344, ISSN 0034-5288, <https://doi.org/10.1016/j.rvsc.2019.07.015>.

[42]. Teja PK, Mithiya J, Kate AS, Bairwa K, & Chauthi SK. Herbal nanomedicines: Recent advancements, challenges, opportunities and regulatory overview. *Phytomedicine: international journal of phytotherapy and phytopharmacology*. 2022; 96, 153890. <https://doi.org/10.1016/j.phymed.2021.153890>.

[43]. Sutil SC, Astesano A, Vogt MV, Torres CV. *Minthostachys verticillata*: toxicity of its essential oil and major constituents to *Artemia salina* and cell lines. *Molecular Medicinal Chemistry IDECEFYN* 2006;10:41-42.

https://www.researchgate.net/publication/239591666_Minthostachys_verticillata_toxicity_of_its_essential_oil_and_major_constituents_to_Artemia_salina_and_cell_lines.

[44]. Escobar FM, Cariddi LN, Sabini MC, Reinoso E, Sutil SB, Torres CV, Zanon SM, Sabini, LI. Lack of cytotoxic and genotoxic effects of *Minthostachys verticillata* essential oil: studies in vitro and in vivo. *Food Chem Toxicol*. 2012; 50: 3062-3067. <http://dx.doi.org/10.1016/j.fct.2012.06.018> | Medline

[45]. Escobar FM, Sabini MC, Cariddi LN, Sabini LI, Mañas F, Cristofolini A, Bagnis G, Gallucci MN, Cavaglieri RL. Safety assessment of essential oil from *Minthostachys verticillata* (Griseb.) Epling (peperina): 90-day oral subchronic toxicity study in rats. *Regul Toxicol Pharmacol*. 2015; 71, 1-7. <http://dx.doi.org/10.1016/j.yrtph.2014.11.001> | Medline.

[46]. Abd Rashed A, Rath, DG, Ahmad Nasir NAH, Abd Rahman Z. Antifungal Properties of Essential Oils and Their Compounds for Application in Skin Fungal

Infections: Conventional and Nonconventional Approaches. *Molecules* (Basel, Switzerland). 2021;26(4), 1093. <https://doi.org/10.3390/molecules26041093>

[47]. Caneschi A, Bardhi A, Barbarossa A, Zaghini A. Plant Essential Oils as a Tool in the Control of Bovine Mastitis: An Update. *Molecules* 2023; 28: 3425. <https://doi.org/10.3390/molecules28083425>.

[48]. Asadpour R, Moradlu M. An update and comprehensive review of the plant extracts and essential oils as a potential treatment for bacterial mastitis in dairy cattle. *Journal of Zoonotic Diseases*. 2023; 7 (X): X doi: 10.22034/jzd.2023.15843 https://jzd.tabrizu.ac.ir/article_15843.html.

[49]. Rivera D, Allkin R, Obón C, Alcaraz F, Verpoorte R, Heinrich, M. What is in a name? The need for accurate scientific nomenclature for plants. *J Ethnopharmacol*, 2014;152(3): 393–402. ISSN 0378-8741, Ontem, foto com meus 2 filhos 1 filha e 6 de meus 7 netos....<https://doi.org/10.1016/j.jep.2013.12.022>.

[50]. Duncney EA, Irving J, Allkin R, Robinson N. Common mistakes when using plant names and how to avoid them. *Eur J Integr Med*. 2016; 8(5):597-601. doi: 10.1016/j.eujim.2016.09.005. PMID: 29057020; PMCID: PMC5646648.

[51]. Gardner Z, McGuffin M. Eds. The American Herbal Product Association's book Herbs of Commerce. 2000; 2nd ed.

[52]. Scandaliaris M, Fuentes E, Lovey RJ. Two species of Lamiaceae commercialized in Córdoba (Argentina) under the name "Peperina". *Argentina Alma/SFX Local Collection Multequina*. 2007;16(1):73-78.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The author contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

The present article does not have any specific funding source. The author is grateful to the IPEN from the Brazilian National Nuclear Commission (CNEN) and CAPES for support.

Conflict of Interest

The author has no conflict of interest to declare that is relevant to the content of this article.

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