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CHEMICAL CONSTITUENTS AND BIOLOGICAL ACTIVITIES OF ESSENTIAL OILS OF THE SPECIES *Malva sylvestris* and *Pelargonium graveolens*: A REVIEW

CONSTITUINTES QUÍMICOS E ATIVIDADES BIOLÓGICAS DE ÓLEOS ESSENCIAIS DAS ESPÉCIES *Malva sylvestris* e *Pelargonium graveolens*: UMA REVISÃO

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ABSTRACT

Certain medicinal plants have popular names similar to each other. *Malva sylvestris* and *Pelargonium graveolens* are species by the same popular name "Malva", and therefore commonly confused, in addition to being used for similar medicinal purposes. The objective of the work was to perform a literature review of the last ten years on the development of scientific knowledge of essential oils of *M. sylvestris* and *P. graveolens*, with an important to identify the main chemical components and biological activities. The results describe the commercial production of these essential essentials, where *P. graveolens*, which is also popularly known as geranium or mallow has a strong therapeutic effect in its composition. As for chemical components, fatty acids: linolenic acid, linoleic acid and palmitic acid are major constituents of *M. Sylvestris* oils. While *P. graveolens* is composed mainly of citronelol, geraniol, citronellate formate and menthol. The main activities reported were antimicrobial, antifungal, insecticide and antioxidant.

Keywords: Essencial oils. *Malva sylvestris. Pelargonium graveolens.*

RESUMO

Determinadas plantas medicinais possuem nomes populares semelhantes entre si. *Malva sylvestris* e *Pelargonium graveolens* são espécies conhecidas pelo mesmo nome popular "Malva" e, portanto, comumente confundidas, além de serem usadas para fins medicinais parecidos. O objetivo do trabalho foi executar uma revisão da literatura dos últimos dez anos sobre o desenvolvimento do conhecimento científico de óleos essenciais de *M. sylvestris* e *P. graveolens*, com a finalidade de identificar os principais componentes químicos e atividades biológicas. Os resultados descrevem a produção comercial destes óleos essenciais, no qual *P. graveolens*, que também é conhecido popularmente como gerânio ou malva-cheirosa, possui um forte efeito terapêutico em sua composição. Quanto aos componentes químicos, os ácidos graxos: ácido linolênico, ácido linoléico e ácido palmítico são constituintes majoritários dos óleos de *M. Sylvestris.* Enquanto *P. graveolens* é composto principalmente de citronelol, geraniol, formiato de citronelila e mentona. As principais atividades relatadas foram: antimicrobiana, antifúngica, inseticida e antioxidante.

Palavras-chave: *Malva sylvestris.* Óleos essenciais. *Pelargonium graveolens.*

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INTRODUCTION

Natural products can be isolated in the form of essential oils, also known as essences, volatile oils, oleoresins, resinoids, or ethereal oils (SERRANO; FIGUEIREDO, 2018). Essential oils are hydrophobic volatile liquids extracted from plants, most often rich in aromas. They are a mixture of secondary metabolites, usually terpenoids, that play an important role in the plant's defense system (MISHRA *et al.*, 2020).

Essential oils are identified with the advantage of being safe and non-toxic. The Federal Drug Administration (FDA) falls under the 'GRAS' (Generally Recognized as Safe) category and their components are well known for a variety of activities, including antimicrobial, antiviral, antifungal, and antibacterial (KULKARNI *et al.*, 2020).

Medicinal plants often receive regional or popular nomenclature, and this often causes misunderstanding in both dispensing and administration (MARTINS, 2015). In Brazil, several plants are known as "malva" and are widely used in the treatment of diseases. Among these plants, there is *Malva sylvestris* (Malvaceae), known as Malva-comum (MARTINS, 2017), and *Pelargonium graveolens* (Geraniaceae) which, despite being from another family, is known in Brazil as Geranium or Malva-cheirosa (GELALETI, 2019).

M. sylvestris and *P. graveolens* are popular species and their essential oils are widely used in the pharmaceutical, agricultural, and cosmetic industries. They are often confused and, in ethnobotanical studies, both show anti-inflammatory activity, however, they act specifically on different tissues (MARTINS, 2015). Romitelli and Martins (2013) justify the confusion between these species due to the similarities in leaf morphology and in their studies they detect anatomical differences, assisting in the taxonomy and classification of these species.

M. Sylvestris has been used in chemotherapy treatments, anti-inflammatory and in various types of infections, mainly, in mucosal areas such as the vaginal and oral mucosa (CRUZ *et al.*, 2018), besides being cited for stomach pain (NEDOPETALSKI; KRUPEK, 2020). While *P. graveolens* presents therapeutic properties and indications, such as anti-aging and relaxing, acne-fighting, antiseptic, astringent and antifungal action (GELALETI, 2019).

With this, this work aims to report the main chemical constituents and biological activities of the essential oils of the species *M. sylvestris* and *P. graveolens*, as well as analyze the relationship between them, due to the importance of this information to avoid confusion in popular medicine and the research of new products with biotechnological potential.

METHODOLOGY

The present work is an updated bibliographic review. The search was conducted by books, book chapters, dissertations, theses, and articles conducted in the Scielo, PubMed, Science Direct, and Google Scholar databases, in Portuguese and English language, with the following keywords: "Malva" "*Malva sylvestris*", "*Pelargonium graveolens*", "Essential oils". Publications were included between the period January 2010 to July 2020. Data analysis was performed in three stages:

In the first stage, the titles of the articles have found were read, and those that presented terms related to the species and obtaining essential oils were selected.

In the second step, the publications were analyzed by reading the Abstracts, selecting those that mentioned any study on the bioactive potential, and analysis of the chemical components of the essential oils of the species of interest.

In the third step, the articles (Tables 1 and 2) were read in their entirety and evaluated in order to select those that proved the biological activity of the essential oil, as well as its chemical constitution, using the approach of qualitative aspects.

DEVELOPMENT

Malva sylvestris (Malvaceae)

Malva sylvestris (Figure 1) is popularly known as Malva, common mallow, wild mallow, green mallow, wild mallow, belongs to the family Malvaceae (BARROS *et al.*, 2010; BOHNEBERGER; MACHADO; DEBIASE, 2019). It can be found in the European, African, and American continents. In Brazil, reports on the distribution of this Malva species were not found. It has a monograph in the Brazilian Pharmacopoeia, being one of the plants of interest by the Unified Health System (SUS) and its consumption approved by the National Health Surveillance Agency (ANVISA) (BRASIL, 2015).

Figure 1 - Malva (*Malva sylvestris* L., Malvaceae): details of the flower and leaf, general aspect of the flowering branch

Source: UTAD (2015).

It is a species of herbaceous habit, characterized by 40 to 70 cm in height, stem with fibrous, hairy, and branched bark, simple leaves 7 to 15 cm long, with palmately nerved and coated with rough trichomes. The flowering season occurs between spring and summer and the flowers reach two to four centimeters in diameter, with purple coloration or shades of pink (DAMEDA; FREITAS; REMPEL, 2014).

Its leaves, flowers, and roots are used for pharmacological purposes (RAZAVI *et al*., 2011; ALELUIA *et al.*, 2014). Especially, its flowers and leaves are edible and used in salads and soups (SPONCHIADO, 2015). According to Barros *et al*. (2010), mallow leaves are used macerated or chewed, also in the form of infusion, steam, syrup, or ointments.

Reports of *M. sylvestris* used in folk medicine in Brazil and other countries are found for the treatment of colitis and stomatitis, in cases of chronic bronchitis, against boils, burns, toothache, bruises, hemorrhoids, as well as other inflammatory processes (AL-RUBAYE; KAIZAL; HAMEED, 2017). Such pharmacological and biological activities can be attributed to the presence of anthocyanidins, naphthoquinones, flavonoids, or mucilaginous polysaccharides that are in large quantities in the fruits, flowers, leaves, and roots of the plant (RAZAVI *et al.*, 2011).

Malva sylvestris (Malvaceae) - Chemical Constituents of Essential Oils

The essential oils, described in this research (Table 1), present different extraction methods. Regarding the analysis of chemical compositions, gas chromatography coupled to mass spectrometry (GC/MS) is performed as the main technique.

Table 1 - Essential oil characteristics of the species *Malva Sylvestris*

Used Part	**Extraction Method**	**Major constituents**	**Biological activity of the oil**	**Origin of the plant**	**References**
Seeds	Solvent extraction (Soxhlet)	Linoleic acid: (49.906%) Palmitic acid: (22.115%) Oleic acid: (15.273%)	Antimicrobial	Tremecém – Algeria	Sabri, Belarbi e Sabri (2013)
Leaves and Stems	Solvent extraction (Soxhlet)	Leaves: Linoleic acid: (43,07-50.15%) Stems: Palmitic acid: (22.95-22.97%)	Antioxidant	Ilam, Dehloran e Dezful - Iran	Tabaraki, Yosefi e Gharneh (2012)
Flowers	Hydrodistillation	Hexadecanoic: (10.1%) Pentacosane: (4.8%) 6,10,14-trimetil-2-pentadecanona: (4,1%)	---	Osaka -Japan	Usami *et al.* (2013)
Leaves and Flowers	Steam distillation	Leaves: Eugenol: (46.7%) Phytol: (34,4%) Flowers: 3-methyl tricosane: (14.9%)	Antimicrobial	Artern - Germany	Cecotti *et al*. (2016)
Aerial parts	Hydrodistillation	4-Vinyl guaiacol: (19.2%) Eugenol: (14.9%) Heptacosan: (15,1%) Linolenic acid: (35.5%) Palmitic acid: (25,6%)	Anti-inflammatory and antimicrobial activity	Molise - Italy	Delfine *et al.* (2017)

Source: the author.

The chemical composition of *M. sylvestris* essential oils is known to show a significant percentage of fatty acids and hydrocarbons (DELFINE *et al.*, 2017). Hexadecanoic acid (USAMI *et al.*, 2013), linolenic acid, linoleic acid, and palmitic acid (BARROS *et al.*, 2010; LOIZZO *et al.*, 2016) frequently are found.

Sharifi-Rad *et al.* (2019) conducted a literature survey on the phytochemical analysis of *M. sylvestris* and their findings showed a few papers evaluating the composition of essential oils. The presence of malvone A, a naphthoquinone, other known monoterpenes, aromatic compounds, and tetrahydroxylated acyclic diterpenes was described, in addition to the presence of polysaccharides, coumarins, flavonoids, malvidin 3- (6″-malonylglucoside) -5 - glycoside, malvaline, scopoletin, polyphenols, niacin, folic acid, vitamins A, C and E, and tannins. Terpenoids such as sesquiterpenes, diterpenes, and monoterpenes are also reported.

Sabri, Belarbi, and Sabri (2013) observed significant antimicrobial activity of the essential oils from *M. sylvestris* seeds, against *Enterococcus feacalis* and *Listeria monocytogenes* strains. The main constituents were: linoleic acid (49.906%), palmitic acid (22.115%), oleic acid (15.273%). The yield obtained was 9%, by the Soxhlet extraction method. In another work, conducted by Tabaraki, Yosefi, and Gharneh (2012), also using the Soxhlet extraction method, it was proven that the antioxidant capacity of *M. sylvestris* leaves and stems is comparable to spinach. The predominant fatty acids were linolenic, linoleic, palmitic, and oleic acid, accounting for 82% of the total fatty acids.

Usami *et al.* (2013) investigated the composition of the aroma in the flower of *M. sylvestris*, obtained by hydrodistillation and analyzed by gas chromatography coupled to mass spectrometry (GC-MS), gas chromatography coupled to olfactometry (GC-O), and analysis of the aroma extract dilutions (AEDA), obtaining a yield of 0.039%. Its major compounds were: hexadecanoic acid (10.1%), pentacosane (4.8%), and 6,10,14-trimethyl-2-pentadecanone (4.1%). The component described as responsible for the aroma of the plant is β-damascenone.

Cecotti *et al.* (2016) investigated flowers and leaves of *M. sylvestris* by steam distillation, the yields were 0.019% for leaves and 0.012% for flowers. Eugenol was the most abundant compound in the leaves, with 46.7% of the total oil, followed by phytol with 34.4%. The flowers showed a predominance of hydrocarbons, among them 3-methyl tricosane. The authors also showed greater antimicrobial activity of the essential oils when compared to the isolated compound, eugenol. This may be caused by a probable synergistic effect between eugenol and the other constituents of the oil, contributing to an increase in the biological activity against *Paenibacillus larvae* and *Melisococcus Plutonius*, pathogens of bees (*Apis mellifera*).

Delfine *et al.* (2017) studied *M. sylvestris* under different environmental conditions, grown at sixteen sites in south-central Italy (Molise), demonstrating that the crop performance was influenced by altitude and mainly by soil fertility and water supply. The authors obtained different yields (0.20±0.021 - 0.05±0.002%) of hydrodistillation extraction for samples of the aerial parts of the plant. The essential oils showed good anti-inflammatory and antimicrobial activity. All samples presented phenolic compounds and fatty acids in their compositions, however, the percentages in each environment were different, which is high altitude and low temperatures presented higher amounts of hydrocarbons (51.3%), and in places with high temperatures, higher amount of phenols (34.1%). The main components were: 4-Vinyl guaiacol (19.2%), Eugenol (14.9%), Heptacosan (15.1%), Linolenic acid: (35.5%), Palmitic acid: (25,6%).

Pelargonium graveolens (Geraniaceae)

Pelargonium graveolens L. (Geraniaceae) (Figure 2), popularly known as geranium or hawthorn mallow, is an aromatic species native to South Africa (RUSSOMANNO *et al.*, 2013; HAMIDPOUR *et al.*, 2017). The sweet and warm aroma, similar to rose petals has high commercial value, being known as geranium oil, it is used as therapeutic (aromatherapy), in the cosmetics and perfumery industries (ARRIGONI-BLANK *et al.*, 2011; HABER, CLEMENTE, 2013). Currently, China is the largest producer of the essential oil of *P. graveolens*, other countries such as India, Egypt, Morocco, and Algeria also represent a good part of the world's production (SANDASI *et al.*, 2011).

It is an herbaceous perennial plant up to 1.3 m tall with a cylindrical stem. The leaves are broadly petiolate, containing 5 to 4 lobes, rounded or cordate-ovate with toothed edges (PRADEEPA; KALIDAS; GEETHA, 2016). It has hairy stems when is a seedling, becoming woody with age. The leaves are light green, spiny, sculptured, velvety, and have a strong citrus aroma. The flowers are small, usually pink in color (SZUTT; DOŁHAŃCZUK-ŚRÓDKA, 2018).

Figure 2 - *Pelargonium graveolens* L. (Geraniaceae): details of the flower and leaf, the general appearance of the flowering branch

Source: UTAD (2015).

*P. graveolen*s is known to be an essential oil-rich plant, and is one of the top 20 essential oils in the world (NILOFER *et al.,* 2018). Research on active molecules of these oils have proven good antifungal, anti-inflammatory, antioxidant activity, and antimicrobial effect (NEAGU *et al.,* 2018; SADIKI *et al.,* 2019), and it is used as an expectorant, respiratory tract ailments and to combat anxiety and menopausal problems (HABER, CLEMENTE, 2013).

Scientists have found a significant reduction of glucose levels by oral administration of *P. graveolens* essential oil, thus exerting hypoglycemic effect (BOUKHRIS *et al.*, 2012). Džamić *et al.* (2014) determined the constituents of commercial geranium essential oil and evaluated its antifungal and antioxidant activity. They observed that the essential oil was effective against *Candida albicans* strains and five *Aspergillus* strains. Through a comparison, they concluded that in this work the antifungal activity was more pronounced than the antioxidant activity. In recent work, it was shown that the essential oil of *P. graveolens* can considerably reduce the feeling of fear and nervousness at the time of childbirth (FAKARI *et al*., 2015).

Pelargonium graveolens (Geraniaceae) - Essential Oil Chemical Constituents

Even though it is in common use, there are still few studies in the areas of medicine that have investigated the therapeutic results inherent in the use of *Pelargonium graveolens* essential oil for various health conditions, as well as the association of these results with the chemical constituents of the oil (MONTIBELER *et al.,* 2018).

The diversity of chemical compounds encompasses flavonoids, phenolic acids, tannins, and coumarins (SARASWATHI *et al.,* 2011; ASGARPANAH; RAMEZANLOO, 2015). The main components present in the essential oil (Table 2) of this species are citronellol, geraniol, linalool, citronellyl formate, mentone, iso-mentone, and nerol (SZUTT; DOŁHAŃCZUK-ŚRÓDKA; SPOREK, 2019).

Niculau *et al.* (2013) concluded that the essential oils of *P. graveolens* introduce insecticidal activity on third instar larvae of *Spodoptera frugiperda*. In its composition, geraniol (23.1%), linalool (11.2%), and citral (2.0%) are found as majority components. Based on the data, it was found that the high toxicity of the essential oil may be associated with the presence of high percentages of geraniol, which caused 30% larval mortality.

Boukhatem, Kameli, and Saidi (2013) evaluated the antimicrobial activity of *P. graveolens* essential oil which showed a good inhibitory effect against *Candida* strains, which suggested its use

in food as natural preservatives against food fungi. The main constituents were citronellol (30.2%), citronellil formate (9.3%), and geraniol (7.6%).

Table 2 - Characteristics of the essential oils from the species *Pelargonium graveolens*

Used Part	Extraction Method	Major constituents	Biological activity of the oil	Origin of the plant	References
Leaves	Hydrodistillation	Geraniol: (23.1%) Linalool: (11.2%) Citral: (2.0%)	Insecticide	São Cristóvão - Brazil	Niculau *et al.* (2013)
Aerial parts	Hidrodestilação	Citronellol: (30.2%) Citronellil formate: (9.3%) Geraniol: (7.6%)	Antimicrobial	Blida - Argelia	Boukhatem, Kameli e Saidi (2013)
Leaves	Solid phase microextraction (SPME) and hydrodistillation	SPME: Citronellol: (8.15%), citronellyl formate: (15.41%) and mentone: (15.21%). Hydrodistillation: Citronellol: (24.45%) Citronellyl formate: (13.57%) Mentone: (12.95%)	Hipoglycemic and hypolipidemic	Amman - Jordan	Afifi *et al.* (2013)
Leaves and Stem	Hydrodistillation	Geraniol: (50.2%) Citronellol: (14.2%)	Antimicrobial	Sarajevo - Bosnia	Carmem, Hancu (2014)
Flowers	Hydrodistillation	Citronellol: (33.49%) Geraniol: (15.08%) Citronellil formate: (7.10%) *Iso*-mentone: (5.1%) Linalool: (4.69%) 10-epi-γ-eudesmol: (3.97%) Mentone: (3.1%) Geranyl formate: (2.88%)	Anesthetic potential	u-ka Defne Essencia - Turkey	Can *et al*. (2018)
Aerial parts	Hydrodistillation	Citronellol: (25.24%) Geraniol: (23.36%) Citronellil formate: (8.35%) Linalool: (7.11%) β-eudesmol: (6.13%) Geranyl formate: (4.26%) *Iso*-mentone: (3.37%)	Antifungal	Agadir - Morocco	Moutaouafiq *et al*. (2019)

Source: the author.

In the study conducted by Afifi *et al.* (2013), hypoglycemic and hypolipidemic activities of *P. graveolens* essential oil extracted from fresh leaves and dried leaves were observed. The techniques used were solid-phase microextraction (SPME) and hydrodistillation. The authors reported that the SPME technique was quite satisfactory when compared to the traditional hydrodistillation technique

since it is faster, simpler, and does not require a solvent. The results obtained showed that there were quantitative and qualitative differences regarding the composition of the oils obtained by SPME and the hydrodistilled oil. However, for both methods, the main constituents identified were oxygenated monoterpenes, being 69.60% by hydrodistillation and 50.17% by SPME.

Carmen and Hancu (2014) observed expressive antioxidant activity of *P. graveolens*, conferring health benefits of the plant. The essential oils of the leaves and stem were obtained by hydrodistillation. By GC-MS analysis, eighty-four essential oil constituents were identified, of which geraniol (50.2%) and citronellol (14.2%) are the majorities.

In unpublished studies, Can *et al.* (2018) evaluated the anesthetic potential of *P. graveolens* essential oil supplied by a commercial company. The results were satisfactory for sedation and anesthesia in fish of the species *Sciaenochromis fryeri* and *Labidochromis caeruleus*, suggesting geranium oil as a new anesthetic for aquaculture. The main components of the oil were citronellol (33.49%), geraniol (15.08%), citronellyl formate (7.10%), iso-mentone (5.1%), linalool (4.69%), 10-epi-γ-eudesmol (3.97%), mentone (3.1%), and geranyl formate (2.88%).

Moutaouafiq *et al.* (2019) to study aromatic and medicinal plants from Morocco, evaluated the antifungal effect of *P. graveolens* essential oil and its fractions against four fungi responsible for wood decay (*Coniophora puteana*, *Coriolus versicolor*, *Poria placenta*, and *Gloeophyllum trabeum*). The essential oil inhibited the development of all fungi tested, suggesting its use for reducing the attack of wood-rotting fungi. The main constituents identified were citronellol (25.24%), geraniol (23.36%), citronellyl formate (8.35%), linalool (7.11%), β-eudesmol (6.13%), geranyl formate (4.26%) and iso-mentone (3.37%).

CONCLUSION

This work described, briefly, the state of the last ten years of knowledge about the essential oils of *Malva Sylvestris* and *Pelargonium graveolens*. With the analysis of the articles, it was concluded that both species present bioactive properties, and, especially *P. graveolens*, a strong therapeutic effect in its composition. However, only *M. Sylvestris* is of interest to SUS, as it is a medicinal plant referenced by the Ministry of Health and Anvisa, being mentioned for the presence of mucilages and dental use.

Although not from the same family, these plants are popularly known as "Malva" and used for similar medicinal purposes. Considering that essential oils have great chemical diversity, the mechanism of action responsible for such effects must be understood, since they present good results in the treatment of diseases, and they have become of interest regarding the pharmacological potential.

The essential oil of *P. graveolens* (geranium) is very popular, and the number of studies investigating its properties is considerably higher than that of *M. Sylvestris*, even though the latter also has commercial production. The extraction methods may vary, however, hydrodistillation appears as a common technique. As for the chemical components, the fatty acids: linolenic acid, linoleic acid, and palmitic acid are the major constituents of *M. Sylvestris* oils. While *P. graveolens* is mainly composed of citronellol, geraniol, citronellyl formate, and mentone. The main activities reported were antimicrobial, antifungal, insecticidal, and antioxidant.

Thus, it is worth noting that in most of the papers consulted for this review, the chemical composition of essential oils or bioactivity were not investigated, indicating that there are not many complete studies on these species.

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