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Review Article

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Phytochemical compounds and pharmacological properties from *Schinus molle* Linnaeus and *Schinus terebinthifolius* Raddi (*Anacardiaceae*)

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ABSTRACT

Anacardiaceae family is composed for 73 genus, with 850 species, containing trees and shrubs. In Brazil, the Schinus molle L. and Schinus terebinthifolius Raddi. are popularly known as Aroeira or Aroeira-pimenteira, and they occur in tropical and subtropical regions around the world. Several classes of compounds can be found in extracts obtained from these plants, such as terpenes (1-terpinen-4-ol) and flavonoids (kaempferol). The essential oil from S. molle L. is rich in monoterpenes and shows interesting antioxidant activity. It showed effectiveness as repellent and acted as hunger inhibitor in Sitophilus oryzae L., popularly known as weevils. Ethanol extract from S. terebinthifolius Raddi present some compounds with pharmacological activity, such as Schinol and 4'-ethyl-4-methyl-2,2',6,6'-tetrahydroxy[1,1'-biphenyl]-4,4'-dicarboxylate, responsible by antifungal activity against the fungus Paracoccidioides brasiliensis. Finally, other substances were isolated from these two species with several biological activities such as antimicrobial, antifungal, insecticidal, repellent, and anti-inflammatory.

Key words: *Anacardiaceae*, *Schinus molle* L., *Schinus terebinthifolius*, phytochemistry, biological activities

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INTRODUCTION

Anacardiaceae family is composed for 73 genus, comprising around 850 species, among trees and shrubs [1]. Plant species of this family are known as fruitful plants with good quality of wood [2]. Many species of this family are commonly found in tropical and subtropical regions [3]. Studies showed the relationship between species from *Schinus spp.* genus and occurrence of contact dermatitis, and this process is related to production of secondary metabolites (alkenyl catechols class), which are substances with allergenic properties [3].

The most well-known plants species utilized in folk medicine are *Schinus molle* L. var. *areira*, and *S. terebinthifolius* Raddi. [2]. *S. molle* L. is also known as California's pepper tree. This plant can reach 10 meters high and it is widespread around the American Continent [1]. The *S. terebinthifolius* is most commonly used with a curative purpose by indigenous from tropical regions [4].

Considering the folk use of these plants in Brazil, as well as its inclusion on the Brazilian National List of Medicinal Plants of Interest to the Unified Health System (RENISUS), which aims to give support for development of researches in phytochemical area and provide information to the Brazilian National List of Medicinal Plants and

Phytotherapics (RENAFITO), allowing the development of new programs in these areas [5]. This review aimed to emphasize the pharmacological actions performed for this two species, based on studies of phytochemical compounds groups found in therapeutic preparations or merely extractives.

EXPERIMENTAL SECTION

Data searches were performed in electronic databases: Scielo, LILACS, PubMed, ScienceDirect and Coordination for the Improvement of Higher Education Personnel (CAPES)/ Ministry of Education (MEC) Periodicals, using: *Schinus molle* AND activity, *Schinus molle* AND phytochemistry, *Schinus molle* AND biological properties, *Schinus terebinthifolius* AND activity, *Schinus terebinthifolius* AND phytochemistry and *Schinus terebinthifolius* AND biological properties, in English, as descriptors, and with a time limit between publications, from 2007 to 2015 (last eight years).

The manuscript selection was based on inclusion criteria: articles published with key words in the title, abstract or in the full text. There was restriction concerning the publication periods and only the works reviewed by pairs were selected. For the selection of the manuscripts, two independent investigators first selected the articles according to title, then to abstract, and then through an analysis of the full-text publication. The resulting articles were manually reviewed with the goal of identifying and excluding the works that did not fit the criteria described above.

RESULTS AND DISCUSSION

3.1 *Schinus molle* L.

Schinus molle L. is a large plant, reaching six feet tall, native from American tropics [6]. At the correct season, produces a fruit-reddish with approximately 5 mm diameter. In some countries, this specie is used as a food. In the Andes, the fruits are utilized for an alcoholic drink production, called *"chichi de molle"* [1]. This specie has a long history of uses in folk medicine around the world, as an ornamental plant in gardens, and in urban landscaping, since they are very resistant to pollution [7]. In Ethiopia, its leaves are used as natural repellents against flies [6]. In Brazil, *S. molle* var. *aroeira* is also used as astringent, diuretic, antispasmodic, and in the plagues control, for example, *Sitophilus oryzae* (L.) [8].

3.1.1 Pharmacological properties

Schinus molle L. is used as anti-rheumatic, anti-septic, anti-inflammatory, antifungal, antimicrobial, wound healing, in the treatment of disorders related to skin [1], and in anti-depressive treatment [7].

a) Leaves and Fruits

Ethanol and petroleum ether extracts of leaves are effectives as topical repellent against *Blattella germanica*, common cockroach. Methanol extract of leaves has antimicrobial activity against *Bacillus subtilis* and *Agrobacterium tumefaciens* [7]. The hexane extracts of leaves and fruits are effective as repellent and insecticidal against nymphs and eggs of *Triatoma infestans*, vector of Chagas disease [6, 9].

b) Essential oil

The essential oil shows significant antimicrobial and antifungal activities. Some studies report that low concentrations of essential oil of this specie, progressively reduce the survival potential of insect plagues, by appetite and oviposition inhibition [6, 10]. The essential oil of leaves is rich in monoterpenes and showed antioxidant activity [1, 11].

Essential oil of leaves, obtained through the steam distillation method, can be used as an effective repellent and acted as hunger inhibitor in *Sitophilus oryzae* L., popularly known as weevils [8]. It also has insecticidal and repellent activity against *Trogoderma granarium*, known as insect pest of rice, and *Tribolium castaneum*, known as brown beetle, attack all types of ground cereals [6]. Finally, the aqueous extract proved to be effective against *Candida albicans* [2].

3.1.2 Phytochemical compounds

a) Fruits

In Figure 1 are shown some commonly phytocompounds found in this species, such as 1-Terpinen-4-ol **(1)**, β-Phellandrene **(2)**, 3-Carene **(3)**, Methyloctanoate **(4)**, 2-Carene **(5)**, α-Humulene **(6)**, Copaene **(7)** [8].

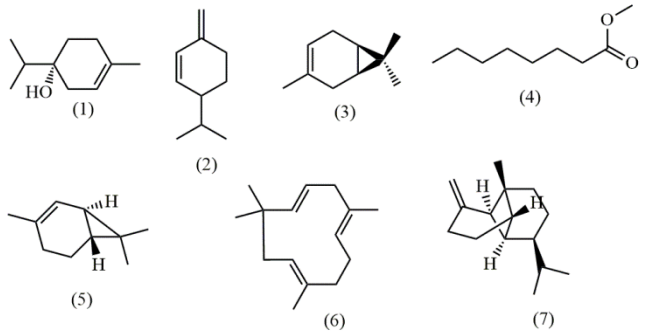

Figure 1: Phytocompounds found in *Schinus molle* L. fruits

b) Leaves

In Figure 2 are shown Elemol **(8)**, *β*-Cubebene **(9)**, *δ*-Cadinene **(10)**, *γ*-Eudesmol **(11)**, *β*-Eudesmol **(12)**, Sabinene **(13)**, Tricyclene **(14)** and Bornyl acetate **(15),** as natural compounds [8].

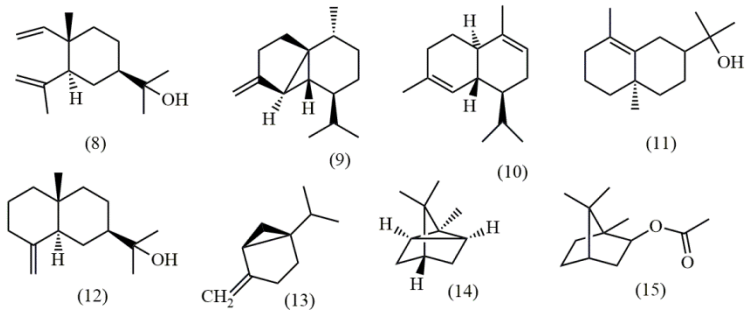

Figure 2: Phytocompounds found in *Schinus molle* L. leaves

c) Leaves and fruits

In Figure 3 are presented several phytochemical compounds, such as Limonene **(16)**, *α*-Phellandrene **(17)**, Camphene **(18)**, *α*-Pinene **(19)**, *β*-Pinene **(20)**, *β*-Myrcene **(21)** and Caryophyllene **(22)** [8].

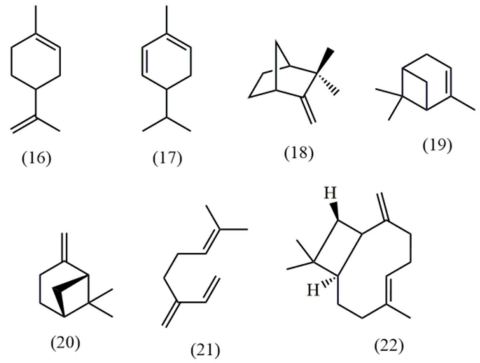

Figure 3: Phytocompounds found simultaneously in *Schinus molle* L. leaves and fruits

Methanol extracts of leaves and bark presented high cytotoxicity in human hepatocytes, *HeG2* cell line. Furthermore, the essential oil of leaves of this same species can present cytotoxicity in fibroblasts, monocytes, neutrophils, and epithelial cells [1].

3.2 *Schinus terebinthifolius* Raddi.

In Brazil, *S. terebinthifolius* Raddi is known as "*Aroeira-pimenteira*", occurs in Rio Grande do Sul and Rio Grande do Norte, and is commonly found on the banks of rivers [2], and can be found in other countries. In France, for example, is known as *"poivre-rose"*, and its fruits are used in cooking, as sweet pepper [2]. The fruits of *S. terebinthifolius* Raddi. are rich in essential oil, which due the sweet taste-spicy, are used in production of syrups, vinegar and alcoholic drinks, in Peru, and wines, in Chile [12].

3.2.1 Pharmacological properties

In South Africa, the tea from leaves is used in the treatment against influenza, and the decoction is inhaled for treatment of hypertension, depression, and arrhythmias [12].

a) Bark
The decoction is utilized in the treatment of rheumatism, and it can be used as antimicrobial, antiviral, anti-inflammatory, hemostat, for urinary and respiratory infections [12].

b) Leaves
Hexane, ethanol, and ethyl acetate extracts presented antimicrobial activity against *Staphylococcus aureus.* Aqueous extract showed potential as growth inhibitor for *Candida albicans.* Ethanol extract presented antioxidant activity [2]. Dichloromethane extract was a strong growth inhibitor of *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Aspergillus niger*, *Aspergillus parasiticus*, and showed low activity against *Escherichia coli* [12]. Crude extract presented antifungal activity against *Paracoccidioides brasiliensis* (responsible for grave infection in respiratory tract), and also, against *Cryptococcus neoformans* and *Sporothrix schenkii* [13]. Furthermore, was reported anti-inflammatory activity [14].

c) Essential oil
Proved to have antioxidant activity when submitted to DPPH assay (2,2-diphenyl-1-picrylhydrazyl), standard assay for evaluation of the radical inhibition potential [12]. Also, showed to have non-steroidal anti-inflammatory activity, acting through inhibition of the A_2 phospholipase. It has larvicidal activity against *Stegomyia aegypti* L. [15].

c) Fruits
The fruits were rich in antioxidant activity and capacity to inhibit the NO synthase production. In addition, showed antimicrobial activity [16].

3.2.2 Phytochemical compounds
There are great varieties of phytochemical components found in this plant, which its concentrations will depend of the type of preparation. In ethanol extract of leaves are found ethyl gallate **(23),** methyl gallate **(24)**, quercetin **(25)**, and miricetrina **(26)** [2].

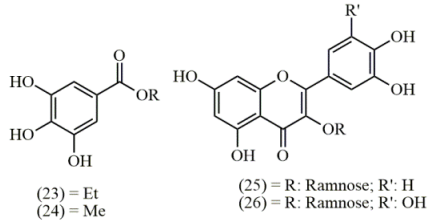

Figure 4: Phytocompounds found in *Schinus terebinthifolius* Raddi. ethanol extract

Also, may be found some important phytocompounds, such as Schinol **(27)** and 4'-ethyl-4-methyl-2,2',6,6'-tetrahydroxy[1,1'-biphenyl]-4,4'-dicarboxylate **(28)**. These two compounds are responsible for antifungal activity against *P. brasiliensis* fungus [8].

Small amounts of sesquiterpenes, such as (-)-*β*-elemene **(29)**; (-)-(*E*)-*β*-caryophyllene **(30)**; Germacrene B **(31)**; *α*-bergamotene **(32)**; (-)-*α*-gurjunene **(33)**; Racemic (±)-germacrene D **(34)**; *α*-humulene; Allo-aromadendrene; *δ*-cadinene; Terebanene **(35)**; Teredenene **(36)**; and Terebinthene **(37)** can be found in fruits essential oil [14].

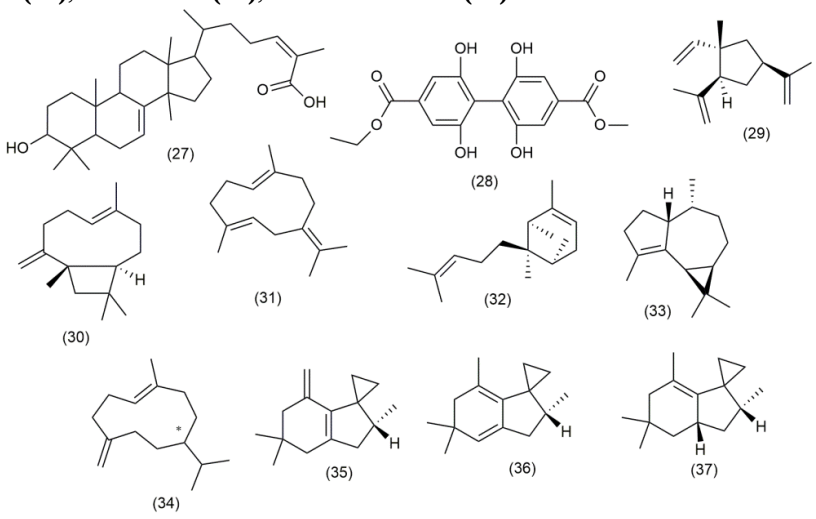

Figure 5: Phytocompounds found in *Schinus terebinthifolius* Raddi. essential oil and ethanol extract

CONCLUSION

S. molle L. and *S. terebinthifolius* Raddi. are plants that have a huge value for countries located in tropical and subtropical regions, where they naturally occur, being this value recognized in agronomy, gastronomy, trade (ornamental gardens), folk medicine and modern medicine, in this case, represented for the research developed out by linked members to RENISUS, for example, the RENAFITO. Finally, the study of plant species phytochemical structure is essential for a better understanding of the pharmacological activities performed for these plants, providing government support in the development new phytotherapy programs and/or new treatment strategies for populations affected by several diseases.

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