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The genus *Eupatorium* L. (Asteraceae): A review of their antimicrobial activity

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In recent years, the number of infectious diseases linked to the occurrence of bacterial and fungal resistance has increased, leading to extensive search for new drugs to treat these infections. Species of the Asteraceae family and the genus *Eupatorium*, have high biological potential and are used in folk medicine to treat various diseases. This review article presents the main phytochemical and biological characteristics of the Asteraceae family and the genus *Eupatorium s.l.*, whose antimicrobial activity is promising, especially antibacterial and antifungal activity. The current review was achieved using an organized search of the scientific data published on antimicrobial activity and phytochemical of the species of the genus *Eupatorium* using various databases, including PubMed, ScienceDirect, Scopus, Scielo, SciFinder and Google Scholar. The species of *Eupatorium* are rich in terpenes, phytosterols and sesquiterpene lactones, the latter being chemotaxonomic markers of the group, with broad anticancer, antiplasmodial and antimicrobial activity, making them promising for the development of new drugs. Various species of *Eupatorium* seems to hold great potential for in-depth investigation for antimicrobial activities. Many species have broad folk use, with scientific confirmation of its antimicrobial properties making these plants potential sources of safer and more effective treatments.

Key words: Compositae, *Eupatorium s.l.*, antimicrobial potential, ethnopharmacology, ethnobotany.

INTRODUCTION

The family Asteraceae, belonging to the class of eudicotyledons, is one of the largest families of angiosperm plants. Its species are known for their therapeutic, cosmetic and aromatic properties and have great importance both from the environmental and economic standpoints. They have been widely studied for their anti-inflammatory, antimicrobial, anticancer, antisyphilitic, antigonorrheal and insecticidal properties (Carrillo-Hormaza et al., 2015). Biological studies of its extracts, oils and constituents for production of phytochemicals have attracting growing interdisciplinary interest from the scientific community (Garcia-Sanchez et
Among several genera of Asteraceae studied, *Eupatorium L. sensu lato* stands out. Numerous studies of its species have been performed and the majority showed the presence of terpenes, phytosterols and sesquiterpene lactones (Liu et al., 2015), the latter identified as promising sources for development of new drugs due to the antimicrobial, anticancer and antiplasmodial action (Albuquerque et al., 2010; Lang et al., 2002).

In a broader context, ethnobotanical and ethnomedicinal studies are very useful for investigation of new bioactive plant sources (Silambarasan and Ayyanar, 2015). Many traditional indigenous communities have longstanding contact with plant species having medicinal properties, with information being transmitted from generation to generation. This information is useful to the scientific community in studies of natural resources, as occurred in studies of *Eupatorium s.l.* (Silva et al., 2012; Paredes-Flores et al., 2007).

Chemical compounds with biological activity isolated from plants and used by the population through extracts are promising sources to prospect for new antimicrobial drugs. These substances may also act synergistically with other drugs, potentially improving the antibiotic action (Al-Fatimi et al., 2007). However, it is necessary to establish whether the traditional use of plants for the treatment of infectious diseases is supported by pharmacological action or merely based on folklore (Pessini et al., 2003).

One obstacle to the treatment of bacterial infections is the phenomena of resistance to antibacterial drugs, caused by the selection of resistant bacteria from exposure to chemotherapeutic agents, causing transfer of resistant gene fragments between bacterial strains and clonal spread of resistant strains among hospitalized patients (Spellberg et al., 2013). The exposure of antimicrobial compound can increase bacterial resistance also by selecting for mutation in genes that help microbes detoxify antibiotics. As for antibiotics, inadequate knowledge of the pharmacokinetic and pharmacodynamic properties, in addition to factors inherent to the patient, such as immune status and non-adherence to treatment, affect the efficiency of chemotherapy against pathogenic bacteria (Muller et al., 2015; Udy et al., 2013).

The use of natural extracts in the treatment of infectious diseases is promising, but studies on antimicrobial activity of different plant extracts should be expanded, including analysis of essential oils and their constituents in order to maximize the effect studied and to discover which chemical compound plays the main role in antimicrobial action (Danielli et al., 2013). In relation to antifungal drugs, natural products are widely used and the results are promising (Cragg and Newman, 2013). Due to the resistance of many pathogenic microorganisms, the search for new antimicrobial agents from plants is intense (Alviano and Alviano, 2009). The relevance of these studies is based on the fact that infections of bacterial etiology, and in particular fungal infections, are aggravated in immunosuppressed individuals, due to therapy against cancer and AIDS and suppression of the immune response to prevent rejection of transplanted organs (Miceli et al., 2011).

For a comprehensive literature overview, the current review was achieved by using an organized search of the scientific data published on antimicrobial activity and phytochemical, focusing on the antibacterial and antifungal activities of the species of the genus *Eupatorium*. The search was conducted using the keyword search term "Eupatorium antimicrobial activity". The searches were carried out using various databases, including PubMed (http://www.ncbi.nlm.nih.gov/pubmed), Science Direct (http://www.sciencedirect.com/), Scopus (http://www.scopus.com/), Scielo (http://www.scielo.org/), SciFinder (https://scifinder.cas.org/) and Google Scholar (http://www.scholar.google.com/).

Based on these considerations, in the present paper, the antibacterial and antifungal potential of species of the genus *Eupatorium s.l.*, were analyzed highlighting also biological properties of the Asteraceae family.

**ASTERACEAE FAMILY**

Asteraceae (Compositae) includes about 1600 genera and 25000 species (Petacci et al., 2012) belonging to 17 tribes and three subfamilies. It is considered by some authors as the largest family of eudicotyledonous angiosperm plants (Nakajima and Semir, 2001; Hattori and Nakajima, 2008). The Asterales order is formed by the Calyceraceae, Menyanthaceae, Goodeniaceae, Campanulaceae and Asteraceae (Judd et al., 2009). This family has been studied intensely over the past 25 years regarding morphology, anatomy, ontogeny and ecology as well as phytochemical, cytogenetic and macromolecular aspects (Hind and Beentje, 1996).

Asteraceae are for the most part herbs, shrubs or shrubs, trees or vines (Roque and Bautista, 2008). Its representatives of greatest importance are *Baccharis trimera* (Less) DC. (gorse), *Matricaria chamomilla* L. (camomile), *Cynara scolium* L. (artichoke), *Vernonia condensata* Baker ("boldo-da-bahia") and *Arnica montana* L. (true arnica). These species are widely used and marketed as herbal products, suggesting species of the family Asteraceae have significant potential as a source of bioactive compounds (Maia et al., 2010; Mello et al., 2008). They are also sources of edible oils (*Helianthus annuus* L., sunflower), pesticides and latex, as well as being eaten as leafy vegetables (e.g., *Lactuca sativa* L., lettuce) and used as ornamental plants (Wu et al., 2006). Phytochemical studies of *Eupatorium* have identified the presence of sesquiterpene lactones, flavonoids, triterpenes, benzofuran compounds,
pyrrolizidine alkaloids, chromene and steroids (Liu et al., 2015; Zhang et al., 2008; Albuquerque et al., 2004; Lang et al., 2001).

**GENUS EUPATORIUM**

The genus *Eupatorium* s.l. (tribe Eupatorieae, subtribe Eupatoriinae) was one of the most representative of the family Asteraceae, containing around 1200 species, however a detailed survey conducted by King and Robinson (1987) found that about 1010 species would be reclassified to different new genera. When interpreted in its traditional concept, this genus form a polyphyletic group. *Eupatorium* s.l. have been a highly artificial concept, tending to include all members of the tribe with a pappus of numerous capillary bristles, five ribs on the achene, and another appendage as long as or longer that wide (King and Robinson, 1987). This genus has been restructured and was fragmented into 80 genera. Currently, the genus *Eupatorium sensu stricto* containing about 45 species, distributed primarily by arctic-tertiary region (King and Robinson, 1987; Bremer, 1994).

The species of this genus are used in folk medicine in different parts of the world (Albuquerque et al., 2010), like Mexico, where over 1000 medicinal plants have been used for over 400 years in folk medicine, many are in the genus *Eupatorium* (García-Sánchez et al., 2011).

Ethnopharmacological studies of medicinal plants are important for the development of new drugs (Silambarasan and Ayyanar, 2015). The main goal is to find new bioactive substances for disease control with minimal side effects (Rodríguez and Carlini, 2003). In this context, studies have been conducted of biological activities such as toxic activity of essential oils (Albuquerque et al., 2004) and plant extracts (Rozo et al., 2008) against the larvae of *Aedes aegypti* and antiplasmodial activity against *Plasmodium falciparum*, a protozoan that causes malaria (Lang et al., 2002).

In particular, the literature contains numerous studies of the genus *Eupatorium* with use of plant extracts and essential oils against strains of bacteria and fungi that infect animals and plants, for development of new drugs for veterinary and human use and new herbicides. Studies were found from 1948 to 2016 with *Eupatorium* species. *E. adenophorum*, *E. odoratum* and *E. triplinerve* are the species with the most work reporting their antimicrobial potential (Table 1).

**Antimicrobial activity of *Eupatorium* s.l.**

Most studies of the antimicrobial activity involved species of Asia and Europe, with fewer studies of South American plants. This is counterintuitive, given that although countries like China, Malaysia, India, Zaire, Indonesia and Madagascar can be considered megadiverse (Sandes and Di Blasi, 2000), species of *Eupatorium* are particularly diverse in tropical and subtropical areas of the Americas (Zhang et al., 2008).

For antibacterial action, tests have been conducted on activity against a wide range of microorganisms, both Gram-positive and negative bacteria. For investigations of plant extracts, the most commonly used solvents are methanol, ethanol, ethyl acetate and n-hexane, used in studies the aerial parts, branches, twigs and leaves. Nevertheless, there are reports of the use of roots to obtain the essential oil of *E. adenophorum* Spreng. (Ahlwualla et al., 2014) and the aqueous extract of *E. purpureum* L. (Carlson et al., 1948; Pates Madsen, 1955), in both cases having antibacterial action.

Referring to antifungal bioassays, the studies focused on *Eupatorium* generally also have involved tests against bacteria. The tested fungi include filamentous fungi, dermatophytes and yeasts. Tests with dermatophytes, filamentous fungi that cause dermatophytosis are promising for the genus, with reports of activity for *Eupatorium arnottianum* Griseb. (Muschielli et al., 2005), *Eupatorium aschenbornianum* S. Schauer (Garcia et al., 2003 Rios et al., 2003), *Eupatorium bunifolium* Hook. and Arn. (Muschielli et al., 2005), *Eupatorium japonicum* Thunb. (Inouye et al., 2006), *Eupatorium lacinatum* Kitam. (Inouye et al., 2006) and *Eupatorium odoratum* L. (Taylor et al., 1996). In all these studies, extracts of plant material were used. There are few reports in the literature on the use of essential oils for susceptibility testing. As for the fungi tested, of the three genera of dermatophytes (*Trichophyton, Microsporum* and *Epidermophyton*), only two showed sensitivity and growth inhibition (*Trichophyton* and *Microsporum*), highlighting species *T. rubrum* and *T. mentagrophytes* in the genus *Trichophyton*.

**Eupatorium adenophorum Spreng.**

The species *E. adenophorum* [syn. *Ageratina adenophora* (Spreng.) R.M. King & H. Rob.], native to Mexico, is now widely distributed in the world (King and Robinson, 1970) and is used in folk medicine as an antimicrobial, antiseptic, analgesic and antipyretic (Bhattarai and Shrestha, 2009). It has also been shown to have molluscicide potential against *Oncomelania hupensis*, the intermediate host of *Schistosoma japonicum* (Zou et al., 2009). The essential oil extracted from the flowers, and roots was tested and showed inhibitory activity for the strains of *Xanthomonas oryzae*, *Erwinia chrysanthemi*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*. Assays were performed using the disk diffusion and agar dilution methods (Ahlwualla et al., 2014). The essential oil extracted from the aerial parts was also investigated against strains of Arthrobacter protophormiae, *Escherichia coli*, *Micrococcus luteus*, *Rhodococcus rhodochrous* and *Staphylococcus aureus*. Assays were performed by broth dilution and the results showed growth inhibition for all strains tested (Kurade et
Table 1. Species of the genus *Eupatorium* s.l. with antimicrobial activity.

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Part used</th>
<th>Biological preparation</th>
<th>Bioactive compounds</th>
<th>Biological activity</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Eupatorium adenophorum</em> Spreng.</td>
<td>I, L, St, R</td>
<td>EO, OsE</td>
<td>Terpenoids</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Bhattarai and Shrestha, 2009; Kurade et al., 2010; Kundu et al., 2013; Ahluwalia et al., 2014; Chauhan et al., 2015</td>
</tr>
<tr>
<td><em>Eupatorium altissimum</em> L.</td>
<td>AP</td>
<td>DE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Carlson et al., 1948; Cantrell et al., 1998</td>
</tr>
<tr>
<td><em>Eupatorium arnottianum</em> Griseb.</td>
<td>AP</td>
<td>ME</td>
<td>-</td>
<td>Antifungal activity: filamentous fungi</td>
<td>MuschietTI et al., 2005</td>
</tr>
<tr>
<td><em>Eupatorium aromaticum</em> L.</td>
<td>L</td>
<td>AqE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive bacteria</td>
<td>Pates and Madsen, 1955</td>
</tr>
<tr>
<td><em>Eupatorium aschenbornianum</em> S. Schauer.</td>
<td>AP</td>
<td>HE, ME</td>
<td>Benzofurans compounds and phytosterols</td>
<td>Antifungal activity: yeast and filamentous fungi</td>
<td>García et al., 2003, Rios et al., 2003</td>
</tr>
<tr>
<td><em>Eupatorium ayapana</em> Vent.</td>
<td>L</td>
<td>PE</td>
<td>Steroids, coumarins, tannins and saponins</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Gupta et al., 2002</td>
</tr>
<tr>
<td><em>Eupatorium ballotifolium</em> Kunth</td>
<td>AP</td>
<td>EO</td>
<td>Terpenoids</td>
<td>Antifungal activity: filamentous fungi</td>
<td>Sobrinho et al., 2016</td>
</tr>
<tr>
<td><em>Eupatorium buniifolium</em> Hook. ex Hook. &amp; Arn.</td>
<td>AP</td>
<td>ME</td>
<td>-</td>
<td>Antifungal activity: filamentous fungi</td>
<td>MuschietTI et al., 2005</td>
</tr>
<tr>
<td><em>Eupatorium cannabinum</em> L.</td>
<td>AP</td>
<td>OsE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Freerksen and Bönice, 1951; Senatore et al., 2001</td>
</tr>
<tr>
<td><em>Eupatorium capillifolium</em> (Lam.) Small.</td>
<td>AP</td>
<td>EO</td>
<td>Terpenoids</td>
<td>Antifungal activity: filamentous fungi</td>
<td>Senatore et al., 2001; Tabanca et al., 2010</td>
</tr>
<tr>
<td><em>Eupatorium fortunei</em> Turcz.</td>
<td>AP</td>
<td>AqE</td>
<td>-</td>
<td>Antibacterial activity: Gram-negative bacteria</td>
<td>Li et al., 2010</td>
</tr>
<tr>
<td><em>Eupatorium glutinosum</em> Lam.</td>
<td>AP</td>
<td>HE, ME</td>
<td>Terpenoids</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Lopez et al., 2001; El-Seedi et al., 2002</td>
</tr>
<tr>
<td><em>Eupatorium havanense</em> Kunth</td>
<td>AP</td>
<td>DE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive bacteria</td>
<td>Cantrell et al., 1998</td>
</tr>
<tr>
<td><em>Eupatorium intermedium</em></td>
<td>F</td>
<td>EO</td>
<td>Terpenoids</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bactéria</td>
<td>Czaikoski et al., 2015</td>
</tr>
<tr>
<td><em>Eupatorium inulefolium</em> Kunth.</td>
<td>L</td>
<td>AqE, EE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Pérez and Anesini, 1994; Sanabria-Galindo et al., 1998; Álvarez et al., 2005</td>
</tr>
<tr>
<td><em>Eupatorium japonicum</em> Thunb.</td>
<td>L, F</td>
<td>EA</td>
<td>Terpenoids</td>
<td>Antifungal activity: filamentous fungi</td>
<td>Inouye et al., 2006</td>
</tr>
<tr>
<td><em>Eupatorium laciniatum</em> Kitam.</td>
<td>L, F</td>
<td>EA</td>
<td>Terpenoids and coumarin</td>
<td>Antifungal activity: filamentous fungi</td>
<td>Inouye et al., 2006</td>
</tr>
</tbody>
</table>
Table 1. Cont’d

<table>
<thead>
<tr>
<th>Eupatorium laevigatum Lam.</th>
<th>L</th>
<th>HE, EE, ME</th>
<th>Alkaloids, steroids, phenols, tannins and flavonoids</th>
<th>Antibacterial activity: Gram-positive and Gram-negative bacteria</th>
<th>Schmidt et al., 2009; Fabri et al., 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eupatorium lindleyanum DC</strong></td>
<td>AP</td>
<td>EE, ME, EA</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Ji et al., 2008</td>
</tr>
<tr>
<td><strong>Eupatorium maculatum L.</strong></td>
<td>AP, S</td>
<td>EE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive bacteria</td>
<td>Bishop and Macdonald, 1951; Borchardt et al., 2008</td>
</tr>
<tr>
<td><strong>Eupatorium odoratum L.</strong></td>
<td>L, AP, F</td>
<td>EE, ME</td>
<td>Polyphenols</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td></td>
</tr>
<tr>
<td><strong>Eupatorium patens D. Don ex Hook. &amp; Am.</strong></td>
<td>L</td>
<td>EO</td>
<td>Terpenoids</td>
<td>Antibacterial activity: Gram-positive bacteria</td>
<td>Bailac et al., 2000</td>
</tr>
<tr>
<td><strong>Eupatorium perfoliatum L.</strong></td>
<td>L, F</td>
<td>EE, PE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td></td>
</tr>
<tr>
<td><strong>Eupatorium purpureum L.</strong></td>
<td>R, St, L</td>
<td>AqE, EE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td></td>
</tr>
<tr>
<td><strong>Eupatorium rugosum Houtt.</strong></td>
<td>L, S</td>
<td>AqE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Frisby et al., 1954</td>
</tr>
<tr>
<td><strong>Eupatorium salvia Colla</strong></td>
<td>AP</td>
<td>RE</td>
<td>Resinous exudate</td>
<td>Antibacterial activity: Gram-positive bacteria</td>
<td>Urzua et al., 1998</td>
</tr>
<tr>
<td><strong>Eupatorium serratum Spreng.</strong></td>
<td>L</td>
<td>ME, EA</td>
<td>Tannins, flavonoids, steroids and alkaloids</td>
<td>Antibacterial activity: Gram-positive bacteria</td>
<td>Desoti et al., 2011</td>
</tr>
<tr>
<td><strong>Eupatorium tashiroi Hayata.</strong></td>
<td>AP</td>
<td>GE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive bacteria</td>
<td>Chen et al., 1989</td>
</tr>
<tr>
<td><strong>Eupatorium triplinerve Vahl</strong></td>
<td>St, L, AP</td>
<td>EO, CE</td>
<td>Terpenoids</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Rahman and Junaid, 2008; Begum et al., 2010; Unnikrishnan et al., 2014; Sugumar et al., 2015</td>
</tr>
<tr>
<td><strong>Eupatorium urticaefolium Reichard</strong></td>
<td>AP</td>
<td>AE</td>
<td>-</td>
<td>Antibacterial activity: Gram-positive and Gram-negative bacteria</td>
<td>Carlson et al., 1948</td>
</tr>
</tbody>
</table>

I- inflorescence; L- leaves; R- root; AP- aerial part; F- flower; St- stems; S- seed; ME- methanol extract; CE- chloroform extract; HE- hexane extract; EE- ethanol extract; PE- petroleum ether extract; DE- dichloromethane extract; EA- ethyl acetate extract; AqE- aqueous extract; AE- acid extract; GE- gross extract; OsE- organic solvents extract; RE- resinous exudate; EO- essential oil.

Extracts from fresh leaves using organic solvents were tested against 15 bacterial strains by the agar diffusion method. The organic extracts showed antibacterial activity against *Salmonella paratyphi*, *Salmonellasp.*, *Staphylococcus aureus*,...
Staphylococcus spp., Bacillus cereus, Bacillus subtilis, Bacillus thuringiensis, Enterobacter aerogenes, Proteus mirabilis and Proteus spp. while the aqueous extract showed activity against P. aeruginosa, E. coli, S. aureus, Staphylococcus spp., Citrobacter freundii. Proteus spp., B. subtilis, E. aerogenes, Salmonella spp., S. paratyphi and B. thuringiensis (Bhattarai and Shrestha, 2009).

Cadinene derivatives extracted from leaves of E. adenophorum showed antifungal activity against four plant pathogenic fungi strains: Rhizoctonia solani, Sclerotium rolfsii, Fusarium oxysporum and Macrophomina phaseolina. Cadinene sesquiterpenes were isolated by column chromatography and preparative thin layer chromatography. Less polar cadinene sesquiterpenes were active against S. rolfsii and polar cadinene derivatives with mono or dihydroxy groups were more inhibitory towards R. solani (Kundu et al., 2013).

Ahuwalia et al. (2014) analyzed the antifungal action of the essential oil of E. adenophorum against five pathogenic fungi: Sclerotium rolfsii, Macrophomina phaseolina, Rhizoctonia solani, Pythium debaryanum and Fusarium oxysporum. They found the strongest inhibitory activity against S. rolfsii. Regarding toxicity, they evaluated the phytotoxic action of the essential oil, which inhibited the growth and seed germination of Phalaris minor Retz. and Triticum aestivum L., used for phytotoxicity assays in a dose-dependent concentration.

In another study, the essential oil from aerial parts exhibited moderated antifungal activity against Fusarium oxysporum by disk diffusion method (Chauhan et al., 2015). Twenty-two components were identified in the composition with an abundance of monoterpenes p-cymene (14.56%) followed by phellandrene (12.25%), camphene (10.42%), bornyl acetate (9.76%) and 8-2-carene (5.39%).

Eupatorium altissimum L.

In a study on the species collected in the state of Louisiana in the United States, a dichloromethane extract was tested against Mycobacterium tuberculosis bacterium, causative agent of most cases of tuberculosis (Cantrell et al., 1998). In a bioprospecting study of 550 plants collected in the states of Ohio and Oregon in the United States, action was reported on the extract of aerial parts of E. altissimum against strains of S. aureus and E. coli (Carlson et al., 1948).

Eupatorium arnottianum Griseb.

E. arnottianum [syn. Chromolaena arnottiana (Griseb.) R.M. King & H. Rob.] is an herb native to Latin America, common in the North-East and Centre of Argentina and South of Bolivia, traditionally used to treat stomach ailments (Clavin et al., 2007), against asthma, bronchitis, colds and topically in plasters for bone fractures and dislocations by healers from the bolivian altiplano (Giraout, 1987), in addition to having anti-inflammatory and analgesic properties (Muschietti et al., 2005).

A methanol extract of the aerial parts showed antifungal activity against the dermatophytes Microsporum gypseum, Trichophyton rubrum and Trichophyton mentagrophytes according to broth microdilution tests (Muschietti et al., 2005).

Eupatorium aromaticum L.

E. aromaticum [syn. Ageratina aromatic (L.) Spach.] is a perennial herb, medium-sized, native to America, common in the southeastern United States, known as “Small-leaved white snakeroot” or “Lesser snakeroot” (Blackwell and Mcmillan, 2013). The ethyl extract of the leaves of E. aromaticum showed antibacterial activity against Gram-positive bacteria (Pates and Madsen, 1955).

Eupatorium aschenbornianum S. Schauer.

E. aschenbornianum [syn. Ageratina pichinchensis (Kunth) R.M. King & H. Rob.] is a plant traditionally used in Mexico to treat skin lesions, mouth ulcers and tumors (Rios et al., 2003). Studies of hexane and methanol extracts obtained from the aerial parts point to the antifungal potential of E. aschenbornianum against the dermatophytes, T. mentagrophytes, T. rubrum, the yeast C. albicans and the filamentous fungus Aspergillus niger (Rios et al., 2003; Garcia et al., 2003).

Yeasts belonging to the genus Candida are involved in the etiology of candidiasis (Netea et al., 2015). Studies on the species E. aschenbornianum showed activity against C. albicans, using hexane and methanol extracts of the aerial parts (Figure 1). Benzo[2,3-d][1,2,4]triazines compounds (5-acetyl-3-β-angeloyloxy-2β-(1-hydroxyisopropyl)-2,3-dihydrobenzofuran and 5-acetyl-3β-angeloyloxy-2β-(1-hydroxyisopropyl)-6-methoxy-2,3-dihy-drobenzofuran) and phytoestrogens were isolated (Rios et al., 2003; Garcia et al., 2003).

Eupatorium ayapana Vent.

The leaves of E. ayapana [syn. Ayapana triplinervis (Vahl) R.M. King & H. Rob.] are used in folk medicine as a heart stimulant, laxative and anticoagulant (Gupta et al., 2002). In rainforests of South America, its leaves are used in decoctions, infusions, tea and baths as tonic, stimulant, sedative, febrifuge and anti-inflammatory, especially in Brazilian folk medicine (Melo et al., 2013). The first preliminary studies of this species were performed by Oswaldo Gonçalves de Lima, then director...
Figure 1. Structures of two benzofurans compounds from aerial parts of *Eupatorium aschenbornianum*. A. 5-acetyl-3β-angeloyloxy-2β-(1-hydroxyisopropyl)-2,3-dihydrobenzofuran. B. 5-acetyl-3β-angeloyloxy-2β-(1-hydroxyisopropyl)-6-methoxy-2,3-dihydrobenzofuran.

of the Antibiotics Institute of the University at Recife, Brazil (Lima, 1963).

The phytochemical study of petroleum ether extract showed presence of steroids, coumarins, tannins and saponins. For the species *E. ayapana*, the petroleum ether extract inhibited growth of bacteria *B. subtilis*, *Staphylococcus epidermidis*, *S. aureus*, *M. luteus*, *E. coli*, *P. aeruginosa*, *Salmonella typhi*, *Shigella* sp., *Vibrio cholerae* and *Vibrio parahaemolyticus*. The extract also inhibited the growth of *A. niger*, *A. flavus*, *Alternaria solani* and *Fusarium solani*, pathogenic fungi causing black mold in fruits and vegetables, deterioration by mycotoxins in grains, alternaria spot in solanaceous plants and root and stem rot, respectively (Gupta et al., 2002).

**Eupatorium ballotifolium** Kunth

*Eupatorium ballotifolium* Kunth (syn. *Lourteigia ballotaeefolia* (Kunth) R.M. King & H. Rob.) popularly known in Brazil by many names, such as “maria-preta”, “maria-preta-verdadeira” and “picão-roxo” is a perennial herbaceous species whose vertical growth ranges from 40 to 80 cm (Cardoso et al., 2013).

The essential oil extracted from the aerial parts, was tested by broth microdilution method and showed antifungal activity against strains fungal dermatophytes, *Trichophyton rubrum*. The chromatographic analysis showed 25 components, accounting for 93.84%, among them mono- and sesquiterpenes, with prevalence of sesquiterpenes (Sobrinho et al., 2016).

The modulatory activity assay was performed to determine the combined effect of the essential oil with the ketoconazole, standard antifungal drug, against strains of *T. rubrum* by the checkerboard technique. The combination of ketoconazole with essential oil reduced the MICs for both strains of *T. rubrum* indicating a synergistic effect (Sobrinho et al., 2016).

**Eupatorium buniifolium** Hook. ex Hook. & Arn.

*E. buniifolium* [syn. *Acanthostyles buniifolius* (Hook. ex Hook. & Arn.) R.M. King & H. Rob.] is a shrubby species widely used in folk medicine, such as to treat rheumatic pains and liver problems with tea obtained by decoction. Preparations from this plant are also used as disinfectants (Ríos et al., 1993).

The methanol extract obtained from the aerial parts was used to investigate antifungal activity against strains of the dermatophytes, *M. gypseum* (MIC = 250 µg/mL), *T. rubrum* (MIC = 100 µg/mL) and *T. mentagrophytes* (MIC = 250 µg/mL). The assays were performed by the broth microdilution method (Muschietti et al., 2005).

**Eupatorium cannabinum** L.

*E. cannabinum* is a perennial herbaceous species distributed in the northern hemisphere, especially in Europe and North America (Senatore et al., 2001). A study of the essential oil of *E. cannabinum* subsp. *cannabinum* L. obtained from the aerial parts identified high percentage of terpenoids, such as germacrene, monocyclic sesquiterpene, found in large amounts. The oil showed antibacterial activity against strains of Gram-positive bacteria (Senatore et al., 2001).

In another investigation, the extract of the aerial parts showed antimicrobial activity against strains of Gram-positive and negative bacteria, the main ones tested being *S. typhi*, *Micrococcus aureus*, *B. subtilis* and
Proteus spp. (Freerksen and Bönicke, 1951).

*Eupatorium capillifolium* (Lam.) Small. ex Porter & Britton

*E. capillifolium* is a perennial herbaceous species found in North America. It is used as food for livestock in the southeastern United States when other fodder is lacking, but it is generally considered a weed (Sellers et al., 2009).

Studies of the effect of plant extracts against pathogenic fungi are important to find new agents against fungi causing plant diseases in agricultural crops. Tabanca et al. (2010) investigated, by contact bioautography, the antifungal activity of the essential oil of *E. capillifolium*, which inhibited growth of the fungus *Colletotrichum acutatum*, the cause of strawberry anthracnose. The main constituents were thymol methyl ether (36.3%), 2,5-dimethoxy-p-cymene (20.8%) and myrcene (15.7%).

*Eupatorium fortunei* Turcz.

*E. fortunei* is a traditional Chinese medicinal herb, common in the northeastern of China, used in folk medicine to treat many diseases (Liu et al., 1992). In a study of bacteria that produce volatile sulfur compounds (VSCs) that cause halitosis, Li et al. (2010) investigated extracts of 40 plants found in China, of which 14 inhibited bacterial growth and production of VSCs. The main compounds found were hydrogen sulfide, dimethyl sulfide and methylmercaptan. Among the 14 plants that were active in the screening was *E. fortunei*, which was used to obtain the aqueous extract.

*Eupatorium glutinosum* Lam.

This species *E. glutinosum* [syn. *Aristeguietia glutinosa* (Lam.) R.M. King & H. Rob.] is widely used in folk medicine, with preparations obtained by decoction used as antimicrobial, antirheumatic and anti diarrheal agents and to heal stomach ulcers (El-Seedi et al., 2002).

The methanol extract of leaves of *E. glutinosum* presented antibacterial activity against strains of *Mycobacterium phlei*, *B. subtilis* and *S. aureus*, by the disk diffusion method (Lopez et al., 2001). The antibacterial activity of the hexane extract of leaves and stems and of two isolated compounds (15-hydroxy-7-labden-17-oic acid and 15-acetoxy-7-labden-17-oic acid) were investigated by diffusion in agar (Figure 2). The tests showed activity against *S. aureus*, *B. cereus*, *E. coli* and *P. aeruginosa* (El-Seedi et al., 2002).

*Eupatorium havanense* Kunth

*E. havanense* [syn. *Ageratina havanensis* (Kunth) R.M. King & H. Rob.] is a native shrub found in North America (Zamudio and Villanueva, 2011) and Central America (Córdoba et al., 1995) known as “Havana snakeroot”. Previous study identified the flavone sakuranetin (Wollenweber and Dietz, 1981) and flavonols, flavones and flavonoid glucosides (Yu et al., 1987).

In an antimicrobial prospecting study of plants of the Americas, the dichloromethane extract of leaves of *E. havanense*, collected in the state of Tamaulipas, Mexico, inhibited the growth of the pathogenic microorganisms *M. tuberculosis* and *M. avium*, the latter an opportunistic pathogen related to infections in immunocompromised individuals (Cantrell et al., 1998).

*Eupatorium intermedium* DC.

*E. intermedium* [syn. *Graziella intermedia* (DC.) R.M. King and H. Rob.] is a branchy shrub, native to southern Brazil with upright growth between 1.0 to 1.5 m high and it is densely leafy until close to the inflorescences, which are composed of white flowers (Czaikoski et al., 2015).
The extracts obtained by supercritical extraction from the flowers with scCO₂, propane and petroleum ether as solvents were tested and showed antibacterial activity against two Gram-positive bacterial strains, *S. aureus* and *L. monocytogenes*, and two Gram-negative bacterial strains, *E. coli* and *S. typhimurium*. The assays were performed using the disk diffusion method (Czaikoski et al., 2015). The extracts were effective against all bacteria strains, particularly the extract obtained with scCO₂ and compressed propane.

The essential oil was tested against Gram-negative bacterial strains using the agar well method. The main constituents of essential oil were α-pinene, sabinene, β-pinene, limonene, (E)-caryophyllene, germacrene D, spathulenol and caryophyllene oxide (Czaikoski et al., 2016).

**Eupatorium inulaefolium** Kunth.

*E. inulaefolium* [syn. Austroeupatorium inulaefolium (Kunth) R.M. King & H. Rob.] is a species found in Latin America, whose common name in Argentina is “sanalotodo” or “yerba de Santa Maria”. This species is used in folk medicine for treatment of skin infections due to its antimicrobial properties (Lancelle et al., 2009) and throat diseases (Álvarez et al., 2005).

In a study of 122 plant species from 54 families, Pérez and Anesini (1994) investigated the antibacterial activity against the microorganism *S. typhi*, causative agent of typhoid fever. Of the plants tested in the initial screening, *E. inulaefolium* showed inhibitory activity against the growth of *S. typhi*. In an investigation of the *in vitro* antimicrobial activity of Colombian angiosperms, the inhibitory activity against the microorganisms *S. aureus* and *B. subtilis*, was investigated at a concentration of 3 mg/mL, by the agar diffusion method (Sanabria-Galindo et al., 1998). In a third study, the ethyl extract of the leaves of *E. inulaefolium* were tested against the strains of *S. aureus*, *E. coli* and *P. aeruginosa*. The authors only observed growth inhibition against *S. aureus*, at a concentration of 50 mg/mL (Álvarez et al., 2005).

**Eupatorium japonicum** Thunb.

*E. japonicum* [syn. Eupatorium chinense L.] is a perennial herb, native to Japan, Korea and northeastern area of China. It is a medicinal herb used in folk medicine as a decoction for the treatment of measles, rheumatic bone pains, colds and cough (Roeder, 2000).

The ethyl acetate extract of the leaves and flowers of *E. japonicum* was used to investigate the antifungal activity against the dermatophyte *T. mentagrophytes*, the most common cause of *Tinea pedis*. At the concentration of 0.25 mg/mL, the authors observed an inhibition zone of 11 mm (Inouye et al., 2006).

**Eupatorium laciniatum** Kitam.

*E. laciniatum* [syn. Eupatorium chinense L.] an annual herbal plant, native to Asia is distributed in the south of China, used in Chinese folk medicine for the treatment of cold, snakebite and inflammation (Yang et al., 2005). The antidermatophytic activity of this plant species was tested against the fungus, *T. mentagrophytes*, using the ethyl acetate extract of the leaves and flowers at a concentration of 0.25 mg/mL. The extract caused an inhibition zone of 12 mm (Inouye et al., 2006).

**Eupatorium laevigatum** Lam.

*E. laevigatum* [syn. Chromolaena laevigata (Lam.) R.M. King & H. Rob.], native to South America is widely distributed in the South part of Brazil and Argentina, whose common name in Brazil is “erva-de-santa-maria” or “camara”, is used in folk medicine for wound healing and as an antifungal (Maia et al., 2002). In Argentina, it is known as “caá-hú” or “doctorcito” and used in folk medicine as an anticefalalgic, analgesic, cathartic, emenagogue and purgative agent (Clavin et al., 2000).

The ethanol and hexane extracts of the leaves were tested against *B. subtilis*, by the agar diffusion method, with moderate results for inhibition of bacterial growth by both solvents (Schmidt et al., 2009). In a chemical and antimicrobial prospecting study, the methanol extract of the leaves of *E. laevigatum* showed the presence of alkaloids, steroids, phenols, tannins and flavonoids. The antimicrobial activity was performed by the broth microdilution method against strains of Gram-positive and negative bacteria, showing inhibitory activity against *P. aeruginosa*, *B. cereus*, *Shigella sonnei* and *Salmonella enterica* sorovar *typhimurium* (Fabri et al., 2011).

**Eupatorium lindleyanum** DC.

*E. lindleyanum* is a perennial herbaceous plant, native to China, known as “Yemazhui” and used in folk medicine to relieve fever, remove toxic substances, treat coughs, promote urination, and lower blood pressure (Xia et al., 2004). In traditional Chinese medicine, its aerial part is used as an antipyretic and detoxicant (Yang et al., 2010).

The extracts of the aerial parts obtained by use of ethanol, methanol and ethyl acetate were tested by the broth dilution method against eight bacterial strains: four Gram-positive (*B. subtilis*, *S. aureus*, *B. cereus* and *E. faecium*) and four Gram-negative (*E. coli*, *S. typhimurium*, *P. vulgaris* and *Pseudomonas fluorescens*). The extracts inhibited growth of all strains tested, with the best results for *B. subtilis*, *S. aureus* and *B. cereus* (Ji et al., 2008).

**Eupatorium maculatum** L.

Native to United States, *E. maculatum* known as “Joe-
“Pye weed” is widely found in moist places, especially in calcareous soils (Goebel et al., 2012). The first report of antimicrobial activity of *E. maculatum* dates back to the work of Bishop and MacDonald (1951), who reported that the ethanol extract of the aerial parts showed activity against strains of Gram-positive bacteria.

In prospective study with 336 native species of the states of Minnesota and Wisconsin in the United States, ethanol extracts of leaves and stems of *E. maculatum* were tested against strains of *S. aureus*, *E. coli*, *P. aeruginosa* and *C. albicans*, presenting significant action only against *S. aureus*. The assays were performed using the disk diffusion method (Borchardt et al., 2008).

**Eupatorium odorum L.**

*E. odorum* [syn. *Chromolaena odorata* (L.) R.M. King & H. Rob.] is a free standing shrub which is mostly distributed in America, tropical Asia and West Africa. It is widely used in traditional medicine as immunomodulator, antispasmodic, hepatoprotective, antiprotozoal, antidiabetic, antihypertensive, anti-inflammatory (Umukoro and Ashorobi, 2014). *E. odorum* also can be used in treatment of skin diseases, dysentery, malaria fever, tooth ache and diabetes (Omogere et al., 2014). In Mexican folk medicine, it is used for chest complaints and pulmonary affections, known as “crucita” (Molina-Salinas et al., 2007).

Various studies of *E. odorum* have investigated the plant’s antimicrobial activity against bacteria that cause various infectious diseases. Cáceres et al. (1995) observed activity against the bacterium *Neisseria gonorrhoeae*, which causes gonorrhea, with an excellent growth inhibition zone.

Four flavanones extracted from flowers of *E. odorum* exhibited antibacterial activity against *Mycobacterium tuberculosis*. Flavanones were isolated by silica gel chromatography and analyzed with infrared spectroscopy and nuclear magnetic resonance (Suksamrarn et al., 2004). Chomnawang et al. (2005) tested the antiancnee activity (crude extracts with chloroform and ethylacetate) against strains of *Propionibacterium acnes*, *S. epidermidis*, while Molina-Salinas et al. (2007) investigated the antibacterial activity (methanol extract; leaves, flowers and roots) against *Streptococcus pneumonia* and Chomnawang et al. (2009) tested it against methicillin-resistant *S. aureus*.

Methanol extract of the aerial parts of *E. odorum* inhibited the growth of *M. philii* by disk diffusion method, with inhibitory activity at concentrations of 300 mg/mL (Gautam et al., 2007). In another study using the aerial parts, the methanol extract inhibited microbial growth of *B. subtillis*, methicillin-resistant *S. aureus*, methicillin-sensitive *S. aureus*, *T. mentagrophytes* and *M. philii*, in the last case only when exposed to UV radiation (Taylor et al., 1996). The essential oil from the dried leaves of *E. odorum* showed *in vitro* antibacterial activity against both Gram-positive and negative bacterial strains (Sharma et al., 2013). The major components analyzed by gas chromatography-mass spectrometry (GC-MS) were geijerene (25.10%), germacrene D (20.27%), trans-β-caryophyllene (10.04%), α-pinene (9.64%) and β-pinene, (4.85%).

In a screening study, the aqueous leaf extract of *E. odoratum* was tested for its fungitoxicity against spores of *Uromyces vignae* and showed the better result for the inhibition of spore germination (Patil and Kamble, 2015).

**Eupatorium patens D. Don ex Hook. & Arn.**

*E. patens* [syn. *Austrobrickellia patens* (D.Don ex Hook. & Arn.) R.M. King & H. Rob.] is a densely branched shrub that is distributed from Bolivia and Paraguay to Patagonia in Argentina, known by the common names of “acancio” or “bejuco” (Cabrera and Corea, 1971).

The essential oil of the leaves was tested against the microorganisms *S. aureus*, *E. coli*, *B. subtillis*, *C. albicans* and *A. niger* by the agar diffusion method. Only the strains of *B. subtillis* showed significant growth inhibition zones after incubation for 24 h (Bailac et al., 2000).

**Eupatorium perfoliatum L.**

Native to North America, *E. perfoliatum* is a medicinal herb, known as “boneset” or “thoroughwort”, used in folk medicine by the native inhabitants for the treatment of fever and flu (Maas et al., 2008). The first record in the literature on the antimicrobial potential of *E. perfoliatum* was performed by Carlson et al. (1948). The authors found that the ether extract obtained from the aerial parts inhibited the growth of *S. aureus*. Later studies investigated extracts from leaves and stems using organic solvents (ethanol, ether and acetone) and water, demonstrating antimicrobial activity against *C. albicans*, Gram-positive and Gram-negative bacteria and *Mycobacterium* spp. (Bishop and MacDonald, 1951; Madsen and Pates, 1952; Liegey, 1953; Frisby et al., 1953).

In prospective study, the ethanol extract of the leaves and flowers of *E. perfoliatum* was tested against strains of *S. aureus*, *E. coli*, *P. aeruginosa* and *C. albicans*. The extract only had significant action against *S. aureus*, with inhibition zones of 11 and 7 mm for extracts of the leaves and inflorences, respectively. The assays were performed using the disk diffusion method (Borchardt et al., 2008).

**Eupatorium purpureum L.**

*E. purpureum* is a wildflower perennial plant, native to the eastern United States, known as “joe-pye weed”, “sweet joa-pye weed”, and “sweetscented joa-pye weed”
(Sabanadzovic et al., 2010). It is used in traditional medicine for rheumatoid arthritis and several other disease conditions (Habtemariam, 1998).

The saline extract of the stems of *E. purpureum* L. showed antibacterial activity against *S. aureus* and *E. coli*, by the agar diffusion method (Carlson et al., 1948). The saline extract of the leaves was also investigated against *S. aureus* and *E. coli*, with positive results by the agar diffusion method (Pates and Madsen, 1955).

**Eupatorium rugosum** Houtt.

*E. rugosum* [syn. *Ageratina altissima* (L.) R.M. King & H. Rob.] is a perennial herb commonly found in the midwestern and eastern United States, known as "white snakeroot" (Lee et al., 2012). The saline extract of the stems of *E. rugosum* showed antibacterial activity against strains of Gram-positive bacteria by the agar diffusion method (Frisby et al., 1954).

**Eupatorium salvia** Colla

*E. salvia* [syn. *Aristeguietia salvia* (Colla) R.M. King & H. Rob.] is a species used in folk Chilean medicine, known as "sálvia macho," "pegajosa" or "pega-pega" (Hoffmann, 1995). The resinous exudate, 7-hydroxy-8(17)-labden-15-oic acid (salvic acid) and 7-acetoxy-8(17)-labden-15-oic acid (salvic acid acetate), isolated from *E. salvia*, were tested against five bacterial strains, with activity against all tested microorganisms: *S. aureus*, *B. cereus*, *B. subtilis*, *M. luteus* and *Clavibacter michiganensis* subsp. *Michiganensis*. These diterpenoids do not affect Gram-negative bacteria and the activity of these compounds on filamentous fungi has not been reported (Urzua et al., 1998).

**Eupatorium serratum** Spreng.

*E. serratum* [syn. *Grazielia serrata* (Spreng.) R.M. King & H. Rob.], popularly known as "erva-milagrosa" or "miraculous herb" in Brazil, is used in folk medicine to treat snake bites, as an analgesic, healing agent, antimicrobial agent and for the treatment of stomach problems, liver disorders, diabetes, cancer and bronchial asthma (Desoti et al., 2011). The hexane, methanol and ethyl acetate extracts obtained from fresh leaves of *E. serratum* were tested against *S. aureus*, *M. luteus*, *E. coli* and *S. typhi*. The best inhibitory halo results were produced by the methanol extract against *M. luteus* (Desoti et al., 2011).

**Eupatorium tashiroi** Hayata

*E. tashiroi*, native to Asia is a wild herb which has been used in a folk medicine for treating edema and hemoptysis in Taiwan (Wu et al., 1985). The aqueous extract of the entire plant was tested by the agar diffusion method against two serotypes of *S. mutans*, bacteria associated with the development of dental caries. The extracts inhibited bacterial growth of both serotypes (Chen et al., 1989).

**Eupatorium triplinerve** Vahl

*E. triplinerve* [syn. *Ayapana triplinervis* (Vahl) R.M. King & H. Rob.] commonly found in Asia is an erect perennial herb with narrow lanceolate leaves and large number of pedicelled flower-heads at the top of the branch, known as "ayapana" (Selvamangai and Bhaskar, 2012). The species was introduced in Indian as ornamental species. In Indian, folk medicine is used as a stimulant, tonic, laxative and for the treatment of yellow fever (Unnikrishnan et al., 2014).

The antimicrobial activities of the essential oil obtained from the leaves and the stem and thymohydroquinone dimethylether were evaluated using disk diffusion assay against strains of Gram-positive and negative bacteria, showing inhibitory activity against *P. aeruginosa*, *S. aureus*, *K. pneumoniae* and *E. coli*. The essential oil showed antifungal activity against fungal strains of *Penicillium chrysogenum* and *C. albicans*; however thymohydroquinone dimethylether only inhibited the growth of *P. chrysogenum* (Unnikrishnan et al., 2014).

The chloroform extract of leaves exhibited antibacterial activity by the broth microdilution and disk diffusion methods against strains of Gram-positive and negative bacteria *Bacillus megaterium*, *B. subtilis*, *B. cereus*, *S. aureus*, *E. coli*, *S. dysenteriae*, *S. sonnei*, *S. typhi*, *S. paratyphi* and *P. aeruginosa*, that exhibited the largest zone of inhibition against *Vibrio* (22 mm in diameter with 1000 µg/disc extract). The antifungal activity was performed with filamentous fungi *Alternaria alternata*, *Curvularia lunata*, *Colletotrichum corchori*, *Fusarium equiseti*, *Macrophomina phaseolina* and *Botryodiplodia theobromae*, with highest inhibition of fungal radial mycelial growth against *C. corchori*, 73.5% with 100 µg extract/ml medium (Rahman and Junaid, 2008).

In others studies, the essential oil from aerial parts and fresh leaves exhibited moderate antibacterial activity against *B. megaterium*, *B. subtilis*, *B. cereus*, *S. aureus*, *E. coli*, *V. cholerae*, *S. dysenteriae*, *S. sonnei*, *S. typhi*, *Pseudomonas* sp. and *S. paratyphi*. The essential oil demonstrated strong antifungal activities against *A. alternata*, *C. lunata*, *B. theobromae*, *C. corchori*, *F. equiseti* and *M. phaseolina* (Begum et al., 2010; Sugumar et al., 2015).

**Eupatorium urticaefolium** Reichard

*E. urticaefolium* [syn. *Ageratina altissima* (L.) R.M. King &
H. Rob.] is a species native to North America, it is commonly found throughout the eastern half of continent. Ingestion of the plant causes a disease called trembles in livestock (Lee et al., 2010). The ethyl acetate extract of the aerial parts of *E. urticaefolium* inhibited the growth of *S. aureus* and *E. coli*, by the agar diffusion method (Carlson et al., 1948).

**Conclusion**

Thirty *Eupatorium* species were identified, some already reclassified to other genera. The aerial parts are the part of plant with more studies and so far the best source for anti-microbial product, being the essential oils and fixed compounds the main natural products. Most of the studies were carried by the broth microdilution and disk diffusion methods, according to Clinical and Laboratory Standards Institute (CLSI).

Microbial infections caused by bacteria and fungi are a growing public health problem, and increasingly common in routine medicine. Outbreaks of infections by methicillin-resistant *S. aureus* in hospital and social environments have been reported in several regions of the world. Regarding fungal infections, the search for new more efficient therapies is particularly urgent considering that the available antifungal chemicals are much less than antibacterial drugs and also typically have more side effects, besides the possible development of fungal resistance.

This review shows that the Asteraceae family, and especially the genus *Eupatorium s.l.*, contains many species with antimicrobial activity, making these plants potential sources of safer and more effective treatments. In short, *Eupatorium s.l.* contains a diverse array of species with antimicrobial potential. New studies involving chemical and biological bioprospecting are necessary to develop effective and less toxic herbal products.

**Conflict of interest**

The authors declare that there is no conflict of interest.

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**REFERENCES**


Hypoglycaemic effect of fractions and crude methanolic leaf extract of *Phyllanthus fraternus* in streptozotocin-induced diabetic and normal rats

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INTRODUCTION

Diabetes mellitus is described by world health organization (WHO) as a group of metabolic diseases in which there are high blood sugar levels over a prolonged period (WHO, 2014). This prolonged high blood sugar levels arises either because insulin production is insufficient, or because the body’s cell do not respond properly to insulin, or both. Patients with high blood sugar will typically experience frequent urination (polyuria),
increasingly thirsty (polydipsia) and distinctly hungry (polyphagia) (Hayat et al., 2010).

Diabetes can cause many complications if left untreated (WHO, 2013). Acute complications include diabetic ketoacidosis and non-ketotic hyperosmolar coma (Kitabchi et al., 2009). Serious long-term complications include cardiovascular disease, stroke, kidney failure, foot ulcers and damage to the eyes (WHO, 2013). Management concentrates on keeping blood sugar levels as close to normal (“euglycemia”) as possible, without causing hypoglycemia. This can usually be accomplished with a healthful diet, exercise, and use of appropriate medications (insulin in the case of type 1 diabetes; oral medications, as well as possibly insulin, in type 2 diabetes). In spite of these advances and effort made towards treating, managing, and perhaps preventing the health, economic and social effects of diabetes mellitus, the prevalence of the disease globally is on the increase. As of 2014, an estimated 387 million people have diabetes worldwide as contained in the report of International Diabetes Federation (IDF, 2014), with type 2 diabetes making up about 90% of the cases. This is equal to 8.3% of the adult population, with equal rates in both women and men (Vos et al., 2013). In the years 2012 to 2014, diabetes was estimated to have resulted in 1.5 to 4.9 million deaths per year respectively (WHO, 2013; IDF, 2014). The number of people with diabetes is expected to rise to 592 million by 2035 (IDF, 2014). The global economic cost of diabetes in 2014 was estimated to be $612 billion USD (IDF, 2013). Hence, there is an urgent need for new therapeutic drug with high efficacy, low cost, little or no side effects and wider availability if this trend must be reversed. Many plants have been studied in search for antidiabetic activity, some components isolated, but with respect to *P. fraternus*, there has been little scientific record to support its anti diabetic activity and to some extent, its active components.

*P. fraternus* belongs to the family Phyllanthaceae. It has been used in folk medicine for the treatment of liver, kidney and bladder problem, intestinal parasites and diabetes (The Wealth of India, 1995). Particularly *P. fraternus* herb is bitter in taste and reported to possess diuretic, hypotensive, hypoglycemic effect, antihyperlipemic, antihepatotoxic and anti oxidant activity (Calixto et al., 1998). An aqueous extract of the leaves lowers blood sugar level in normal and alloxan diabetic rabbits (Ramkrishnan et al., 1982). Different fractions of alcoholic extracts of aerial parts and root of *P. fraternus* were screened for antihepatotoxic activity on carbon tetrachloride (CCL4) induced liver damage (Ahmed et al., 1998). The aim of this study is to analyse qualitatively and quantitatively some phytochemical components of the *P. fraternus* methanolic leaf extract and its fractions and to evaluate the hypoglycaemic efficacy of fractions of methanolic leaf extract of *P. fraternus* on streptozotocin – induced diabetic rats.

**MATERIALS AND METHODS**

**Plant material**

The plant material of *P. fraternus* Webster (Leaves) was collected in the month of May, around 6 am at Hayin gada, in Girei local Government area of Adamawa State which lies on geographical location 9° 21’53.19” North and 12° 33’28.33” East Google earth (2014). It was authenticated by a botanist in the Department of Biological Sciences, Modibbo Adama University of Technology, Yola, Adamawa State.

**Experimental animals**

Male albino rats (5 - 6 weeks) weighing 100 to 130 g numbering 66 were obtained from Veterinary Research Institute VOM, Jos, Plateau State and kept in plastic cages with 12 h dark/light cycle, fed with pelletized grower diet (Vital Feeds, UACN) and given water *ad libitum*. 30 rats were used for prolonged treatment (28 days) while 36 rats were used for OGTT (18 each for diabetic and normal rats).

**Equipments**

The following equipments were used; electronic balance (Golden mettle-2G2-USA), ACCU-CHEK Glucometer (GC-Roche Diagnostic-Germany), ACCU-CHEK test strips (Roche Diagnostic-Germany), spectrophotometer (Vis spectrophotometer 721- PEC Medical USA), water bath (HH-2 B-Scientific), column (5cm diameter), silica gel/TLC- cards (Fluka- Germany).

**Chemicals**

Hexane, dichloromethane and methanol (Sigma-Aldrich Chemie GMBH, Germany), streptozotocin (Tocris Bioscience London), metformin, chloroform, silica gel (Sigma Aldrich-Germany). All other chemicals used were of analytical grade.

**Preparation of plant material**

The fresh plant material (leaf) was washed with tap water and shade dried for seven days. It was made into powder using mortar and pestle. The powdered plant material was used for the preparation of methanolic extract.

**Preparation of methanolic extract**

Methanolic extract was prepared by suspending 200 g of the powdered sample in 2 L of methanol for 24 h with vigorous shaken intermittently, after which it was filtered and then concentrated at 55°C using a water bath (Ugwu et al., 2011).

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Fractionation of the extract by column chromatography

Twenty gram (20 g) of the methanolic leaf extract was subjected to column chromatography for the isolation of the phytoconstituents. Slurry was prepared by dissolving 200 g silica gel in 600 ml hexane (Sarah and Ayesha, 2003).

The fractions were collected and labeled accordingly. Six fractions were obtained, but on subjecting them to thin layer chromatography (TLC), they were pulled together into three broad fractions based on the number of components and retention factor (RF) values of the components in each fraction. The resultant fractions were concentrated by placing them in an oven at a regulated temperature of 40°C. The dried fractions obtained were kept in air tight containers which were later used for OGTT.

Qualitative phytochemical analysis

The qualitative phytochemical screening of the extract was carried out as described by Harborne (1973), Nweze et al. (2004) and Senthilkumar and Reetha (2009). The plant extract was screened for carbohydrates, alkaloids, flavonoids, steroids, phenols, tannins, saponins, terpenoids, glycosides, and proteins.

Induction of diabetes mellitus in rats

All the rats were fasted overnight before the administration of Streptozotocin. Diabetes was induced in rats by intra-peritoneal injection of streptozotocin dissolved in distilled water at a dose of 60 mg/kg body weight (Al-Hariri et al., 2011). After the injection, the rats were allowed free access to food and water. To prevent fatal hypoglycemia due to massive pancreatic insulin release, rats were given 5% glucose solution water for next 24 h (Barry et al., 1997). The animals were tested after 72 h of streptozotocin administration.

The rats with fasting blood glucose more than 300 mg/dl were considered diabetic and were used for the experiment (Akbarazadeh et al., 2007; Parthasarthy and Ilavarasan, 2009).

Experimental design

Evaluation of hypoglycaemic activity following long term treatment: 30 rats (6 normal and 24 diabetic) were divided into 5 groups of six rats each:

- Group 1: Normal control
- Group 2: Diabetic control
- Group 3: Metformin 5 mg/kg b.w.
- Group 4: Diabetic rats treated orally with 200 mg/kg body weight of methanolic leaf extract of *P. fraternus*.
- Group 5: Diabetic rats treated orally with 300 mg/kg body weight methanolic leaf extract of *P. fraternus*

Estimation of fasting blood glucose level was done on a weekly base for four weeks using a glucometer.

The effect of crude and fractions of methanolic leaf extract of *P. fraternus* on oral glucose tolerance test (OGTT) in diabetic rats is determined as shown in Table 1.

The effect of crude and fractions of methanolic leaf extract of *P. fraternus* on oral glucose tolerance test (OGTT) in normal rats is determined as shown in Table 2.

After 30 min of fractions, metformin and crude extract administrations, the rats in all groups were given glucose (2 g/kg body weight). Glucose of blood sample from tail vein was estimated by using glucometer at 0, 30, 60, 90, 120 and 150 min.

Administration of extracts

The extract was administered orally using gastric tube on daily basis for 28 days (long term treatment) while in OGTT, it was a single administration.

Statistical analysis

Values obtained were expressed as mean ± SEM and data were analysed using analysis of variance (ANOVA) with Bonferroni Post
Table 3. Some phytochemicals detected in fractions/crude methanolic leaf extract of *Phyllanthus fraternus*.

<table>
<thead>
<tr>
<th>Phytochemical</th>
<th>Crude</th>
<th>Fraction I</th>
<th>Fraction II</th>
<th>Fraction III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saponins</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Tannins</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Terpenoids</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Glycosides</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Steroids</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phenols</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Protein</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

+ = Present; - = absent.

Table 4. Concentrations of some phytochemicals in methanolic leaf extract of *P. fraternus*.

<table>
<thead>
<tr>
<th>Phytochemical</th>
<th>Concentrations (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saponins</td>
<td>136.00 ± 0.02</td>
</tr>
<tr>
<td>Tannins</td>
<td>37.20 ± 0.02</td>
</tr>
<tr>
<td>Terpenoids</td>
<td>6.60 ± 0.04</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>159.20 ± 0.05</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>96.50 ± 0.01</td>
</tr>
<tr>
<td>Phenols</td>
<td>152.00 ± 0.03</td>
</tr>
</tbody>
</table>

Values are mean ± SEM (n=3).

RESULTS AND DISCUSSION

Qualitative phytochemical screening

Results of the qualitative phytochemical screening of the crude/fractions of methanolic leaf extract of *P. fraternus* are presented in Table 3.

Quantitative phytochemical estimation

Results of quantitative estimation of some of the phytochemicals in *P. fraternus* methanolic leaf extract (Table 4).

Effects of *P. fraternus* methanolic leaf extract on blood glucose level in streptozotocin-induced diabetic rats

In prolonged treatments (28 days) (Figure 1), the fasting blood glucose for all the treatments group (except normal control) were all slightly above 350 mg/dl on the initial day (day 0). However, the curve for diabetic untreated group was shown to be at relatively steady level throughout the treatment period. Other treatment groups have shown decrease in fasting blood glucose level from day 7 of treatments with metformin showing the most hypoglycaemic effect. Treatment with Methanolic extract at 300 mg/kg body weight was shown to have the same hypoglycaemic effect with metformin at day 21 of the treatment. On the final day of treatment (day 28), there was no significant difference among all the treatment groups with the fasting blood glucose level of all groups below 150 mg/dl.

Hypoglycaemic effects of fractions of methanolic leaf extract of *P. fraternus* in Streptozotocin induced diabetic rats

The hypoglycaemic effects of the three fractions (F I, F II and F III) obtained were carried out in diabetic rats following a glucose load and from the result obtained (Figure 2), the blood glucose level increases rapidly in all the groups 30 min after commencement of the glucose tolerance test, but fraction one (FI) and the standard

hoc test multiple comparison versus control groups with help of Statistical Package for the Social Sciences (SPSS) software version 21. The values p< 0.05 were considered significant (Duncan et al., 1977).
control (metformin) were significantly lower at p<0.05 when compared against the diabetic control. There was sharp fall in the glucose level in both metformin and F1 treated groups with F1 treated group giving the most

Figure 1. Effects of methanolic leaf extract of *P. fraternus* on fasting blood glucose level (mg/dl) in Streptozotocin - induced diabetic rats.

Figure 2. Effect of pre-treatment with 200 mg/kgbw of methanolic leaf extract of *P. fraternus* on oral glucose tolerance test in STZ-induced diabetic rats.
glucose tolerance all through the test period followed by metformin. Fraction three (FIII) showed the least hypoglycaemic effect all through the period of the test, at 150 min, FIII and diabetic control showed no difference. On the other hand, crude extract and FII had similar effect at 90 min, but FII maintained a relatively steady level through the remaining period while the crude extract further decreases the glucose level. The crude extracts showed maximum hypoglycaemic effects at 150 min where it exerts similar hypoglycaemic effect with metformin and FI.

**Hypoglycaemic effects of fractions of *P. fraternus* extract in normal rats**

Treatments with different fractions of *P. fraternus* extract prior to glucose load in normal rats have shown positive hypoglycaemic effects after glucose load Figure 3. The control (untreated group) has shown a rapid increase in blood glucose in the first 60 min after glucose load before showing gradual decrease at 90 min and finally going back almost to the initial value at 150 min.

Treatment with metformin (Standard control) and Fraction I prevented glucose induced hyperglycaemia 30 min after commencement of the glucose tolerance test. Treatment with metformin have significantly (p<0.05) lowered the blood glucose level at 30, 60 and 90 min of the tolerance test when compared with other treatments except for fraction I which in all cases showed similar hypoglycaemic effect with the standard control (metformin). More so, fraction I had significantly decreased blood glucose level ahead of the crude extract at 30, 60 and 90 min. All the treatment groups showed similar hypoglycaemic effect at 120 min differing significantly (p<0.05) against the normal control.

**DISCUSSION**

Phytochemical screening of *P. fraternus* methanolic extract revealed the presence of alkaloids, flavonoids,
tannins, saponins, steroids, phenols, carbohydrates, terpenoids and proteins. This finding is similar to the research findings of Matur et al. (2009) and Okon et al. (2005). Plants are considered as biosynthetic laboratory for a multitude of compounds that exert physiological effects (Garg et al., 2010). Earlier reported studies have already confirmed that flavonoids and tannins are the class of compounds which are responsible for several therapeutic activities (Garg et al., 2010; Iwu, 1983). Several Authors also reported flavonoids, steroids, alkaloids and phenolics as bioactive antidiabetic principles (Nadro and Onoagbe, 2012). Fortunately the leaf of Phyllanthus fraternus contains all these bioactive antidiabetic principles in reasonable quantities.

Streptozotocin induced diabetes has been described as a useful experimental model to study the activity of hypoglycaemic agents (Paul et al., 2006). Blood glucose level was increased consistently and significantly in the diabetic untreated groups with relative stability after seven days. This rapid increment may be due to decreased glucose clearance as a consequence of a defect in glucose transport (Wi et al., 1998).

Prolonged treatment (28 days) with methanolic extract of Phyllanthus fraternus (MEP) (200 and 300 mg/kg body weight) and metformin (5 mg/kg body weight) showed continual decrease of blood glucose, suggesting long term maintenance of blood glucose level in diabetic rats. Several medicinal plants have been reported to restore activity of key enzymes of glucose and glycogen metabolism which are strongly disturbed in streptozotocin diabetic rats (Eddouks et al., 2003, Sharma et al., 2010). Hypoglycaemic effect of MEP may arise from the inhibition of hepatic glucose production, or insulin signalling (Qin et al., 2003). Prasad et al. (2009) reported also that the hypoglycaemic action of the extract of herbal plants in diabetic rats may be possible through the insulinomimetic action or by other mechanism such as stimulation of glucose uptake by peripheral tissues, inhibition of endogenous glucose production or activation of gluconeogenesis in liver and muscles.

Fractions obtained from the fractionation of the methanolic extract of Phyllanthus fraternus showed hypoglycaemic effects following a single dose administration at 200 mg/kg body weight in both normal and diabetic rats. Fraction one (F I) had significantly lowered blood glucose level 30 min after glucose load in oral glucose tolerance test in diabetic rats and had favourably competed against metformin all through the 150 min the test lasted. Similarly, in normal rats, F I was able to significantly prevent glucose induced hyperglycaemia better than the other fractions and much better than the crude extract. This suggests that the fractionation has helped to free the hypoglycaemic agent in fraction one (F I) which had consequently exhibited faster hypoglycaemic effect at 30 min even better than metformin (standard drug). Whereas the slow performance of the crude extract suggests that the hypoglycaemic agent is bound with other components that required time to be freed up, hence the maximum effect coming after 2 h, probably, after digestion had taken place to free up the hypoglycaemic agent.

Conclusion

From this study, it can be deduced that flavonoids from Fraction 1 of methanolic leaf extract of Phyllanthus fraternus is a potent hypoglycaemic agent. Similarly, repeated oral administration of methanolic leaf extract of Phyllanthus fraternus was shown to evoke hypoglycaemic effect on the fasting blood glucose profile of streptozotocin induced diabetic rats. These results support the traditional usage of Phyllanthus fraternus in the treatment of diabetes mellitus.

Conflicts of interests

The authors have not declared any conflict of interests.

REFERENCES

Nadro MS, Onoagbe IO (2012). Anti-hyperlipidaemic and antioxidant


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