Revista Brasileira de Farmacognosia
Brazilian Journal of Pharmacognosy
16(Supl.): 696-720, Dez. 2006

Received 03/28/06. Accepted 09/19/06

Revisão

Plants and chemical constituents with giardicidal activity

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RESUMO: "Plantas e constituintes químicos com atividade giardicida". Infecção intestinal causada por *Giardia lamblia* representa grave problema de saúde pública, com elevadas taxas de prevalência em diversos países. O aumento de resistência do parasita e os efeitos colaterais dos fármacos de referência empregados no tratamento da giardíase, tornam necessário a busca de novos agentes terapêuticos. Produtos naturais, especialmente de origem vegetal, representam excelentes fontes de pesquisas. Este trabalho tem como objetivo revisar a literatura de extratos de plantas, frações e compostos químicos com estudos *in vitro* de avaliação da atividade giardicida. A revisão refere 153 (cento e cinqüenta e três) espécies vegetais de 69 (sessenta e nove) famílias que foram submetidas à avaliação da atividade giardicida. Descreve a distribuição geográfica das espécies vegetais, parte usada, preparação, cepa de *Giardia lamblia* testada e resultados por autores. Apresenta 101 (cento e um) compostos isolados de espécies vegetais classificados por classes químicas. Discute aspectos recentes da pesquisa de produtos naturais de origem vegetal empregados no tratamento da giardíase.

Unitermos: *Giardia lamblia*, atividade giardicida, produtos naturais, plantas medicinais, revisão.

ABSTRACT: Intestinal infection caused by *Giardia lamblia* represents a serious public health problem, with increased rates of prevalence in numerous countries. Increased resistance of the parasite and the side-effects of the reference drugs employed in the treatment of giardiasis make necessary to seek new therapeutic agents. Natural products, especially of plant origin, represent excellent starting point for research. The objective of this study is to review the literature on plant extracts, fractions and chemical constituents whose giardicidal activity has been investigated *in vitro*. The review describes 153 (one hundred and fifty-three) plant species from 69 (sixty-nine) families that were evaluated for their giardicidal activity. The geographical distribution of the plant species, the part used, preparation, strain of *Giardia lamblia* tested and the results obtained by the authors are also given. One hundred and one compounds isolated from plant species, classified by chemical class, are presented. Recent aspects of research on natural products of plant origin employed in the treatment of giardiasis are also discussed.

Keywords: *Giardia lamblia*, giardicidal activity, natural products, medicinal plants, review.

INTRODUCTION

Giardiasis is an intestinal infection caused by the flagellate protozoan *Giardia lamblia* (syn: *Giardia intestinalis*, *Giardia duodenalis*) with a broad, worldwide distribution and high rates of prevalence (Thompson et al., 2000; Adam, 2001; Sogayar; Guimarães, 2003). According to the World Health Organization, the worldwide incidence is around 500,000 new cases per year (WHO, 1998). In developed countries, including the United States and Canada, *Giardia lamblia* is the intestinal parasite most commonly associated with outbreaks of diarrhoea (Ortega; Adam, 1997; Tessier; Davies, 1999). In developing countries the average prevalence is 20% among the general population (Ortega; Adam, 1997; Rocha, 2003). In Brazil, some epidemiological studies have registered levels of up to 63.3%, thereby constituting a serious public health problem (Cury et al., 1994; Guimarães; Sogayar, 1995; Newman et al., 2001).

During its evolutionary cycle *Giardia lamblia* presents in both cyst and trophozoital forms. The parasite is transmitted by faecal-oral contamination, through the ingestion of mature cysts present in untreated or inadequately treated water and contaminated foods. Direct person-to-person transmission through contaminated hands is common, mainly in group situations and

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ISSN 0102-695X

among family members. There have also been reports of transmission through anal sex. However, contamination of humans through contact with infected animals is controversial (Adam, 1991; Flanagan, 1992; Nuñez et al., 2003; Rocha, 2003; Sogayar; Guimarães, 2003).

Giardia lamblia infection mainly affects children aged between 0 and 5 years, without distinction of sex, while the number of cases registered is significantly increased among homosexual men and immunocompromised individuals (Adam, 1991; Lebwohl et al., 2003; Sawangjaroen et al., 2005). Among Brazilian patients with acquired immunodeficiency syndrome, *Giardia lamblia* is the most frequent parasite related to intestinal diseases (Cimerman et al., 1999).

The majority of the hosts of *Giardia lamblia* is asymptomatic and plays an important role in the epidemiological chain, since, despite the absence of symptoms, they eliminate cysts, contributing significantly to the transmission of the disease (Tessier; Davies, 1999; Rey, 2001).

The clinical manifestations of giardiasis are varied, with diarrhoea being the predominant symptom, occurring in 90% of symptomatic patients. Diarrhoea may be acute and self-limiting or chronic and debilitating, associated with abdominal pain, flatulence, dyspepsia, epigastric pain, nausea, vomiting, and steatorrhea, malabsorption of fats and fat soluble vitamins and weight loss. The malabsorption of fats, carbohydrates, iron and vitamins (A and B_{12}) retards physical and intellectual development, mainly among younger age groups (Farthing et al., 1986; Heresi et al., 2000; Gendrel et al., 2003; Lebwohl et al., 2003; Al-Mekhlafi et al., 2005).

The treatment of giardiasis consists of the use of one or more drugs, with metronidazole being the first choice. Other nitroimidazolic derivatives (secnidazole, tinidazole, and ornidazole), benzimidazoles (albendazole, mebendazole), furazolin, quinacrine and paromomycin have also been employed in therapeutic regimens. However, these drugs have adverse effects including gastrointestinal disturbances, nausea, headache, leucopoenia and an unpleasant taste in the mouth. Furthermore, they can lead to neurotoxic effects, ataxia, convulsions and vertigo, bringing about the interruption of treatment. In addition, mutagenic and carcinogenic effects have been described in laboratory animals (Morgan et al., 1993; Heresi et al., 2000; Harris et al., 2001; Campanati; Monteiro-Leal, 2002; Petri-Jr., 2003).

Bearing in mind the side effects of the reference drugs and the increased resistance of the parasite to conventional treatment, it has become necessary to seek new, safe and effective agents for the treatment of the infection (Harris et al., 2001; Sousa; Silva, 2001; Upcroft; Upcroft, 2001; Sangster et al., 2002).

Plants represent an important source of drugs, considering the wide diversity of molecules with medicinal potential, and can make an effective contribution to the search of new bioactive products, semi-synthetic medicines or lead compounds for the synthesis of medicines (Cowan, 1999; Yunes; Calixto, 2001; Pinto et al., 2002; Anthony et al., 2005; Gilani; Rahman, 2005). The exploitation of this potential source of medicine requires the bringing together of ethnobotanical, ethnopharmacological, chemical, biological, pharmacological and toxicological studies (Gilani; Rahman, 2005; Gurib-Fakim, 2006).

In the search for new active products of plant origin, literature reviews concerning plant extracts, semi-purified fractions and chemically defined molecules with biological activity have furnished important additional details, making an effective contribution to the definition of inclusion and/or exclusion criteria in the selection of plant species for the development of validation studies (Almeida et al., 2001; Sharma; Sharma, 2001; Pereira et al., 2002; Moura et al., 2002; Morais et al., 2003; Silva et al., 2003; Rocha et al., 2005; Falcão et al., 2005; Barbosa-Filho et al., 2005; 2006a,b; Funke; Melzig, 2006).

With the aim of contributing to the search for new alternatives for the control of *Giardia lamblia* infection, the present work reviews the literature of studies examining *in vitro* giardicidal activity carried out with extracts, fractions and chemical substances of plant origin.

MATERIAL AND METHODS

This review covered Biological Abstracts, Chemical Abstracts, Medline, Web of Science, Lilacs and the data base of the University of Illinois-Chicago NAPRALERT (acronym for NAtural PRoducts ALERT), updated to June 2006. The references obtained in the review were consulted and analysed in details.

The key words employed in the literature review were *Giardia lamblia* x antigiardial activity x giardicidal activity x anti-protozoan activity x medicinal plants x natural products x natural compounds x *in vitro* x plant extracts.

RESULTS AND DISCUSSION

Following the proposed methodology, the study resulted in the elaboration of tables of extracts, fractions and pure chemical compounds that have been evaluated for their *in vitro* giardicidal activity (Tables 1 and 2).

The efficacy of the biological activity of plant materials under analysis can be related to the location and time of collection, the part of the plant used, preparation of the plant material, strain of *Giardia lamblia* tested and the assay employed. Such factors justify the development of studies with the same plant species, but obtained from different localities and/or at different times of collection, to investigate the giardicidal activity with different strains of the parasite, methodology and/or by diverse authors.

Review of the literature showed that the *in vitro* giardicidal activity had been investigated in 153 plant species, distributed among 69 (sixty-nine) families, including a notable representation of Asteraceae, Fabaceae, Rutaceae and Verbenaceae with 25, 10, 7 and 6 species studied, respectively.

Based on the results of the *in vitro* biological assessment according to the concentration of the extracts and fractions tested, we established criteria for the classification of giardicidal activity as highly active ($IC_{50} \leq 100$ µg/mL), active ($100 < IC_{50} \leq 250$ µg/mL), moderately active ($250 < IC_{50} \leq 500$ µg/mL) and inactive ($IC_{50} \geq 500$ µg/mL). The studies which did not give the concentration of the extracts and/or fractions analysed for IC_{50}, IC_{90}, and IC_{100} values and/or MIC, giardicidal activity were classified according to the criteria of efficacy (active or inactive) defined by the authors. Table 2 presents the results for giardicidal activity based on the criteria of efficacy and/or IC_{50} values established by the authors cited.

Giardicidal activity of plant extracts and fractions

Ethnobotanical and ethnopharmacological studies have shown the wide use of plant species in the treatment of gastrointestinal disturbances, such as diarrhoea and dysentery (Ivancheva; Stantcheva, 2000; Singh et al., 2002; El-Hilaly et al., 2003; Alanís et al., 2005; Gilani et al., 2005; Velázquez et al., 2006), which are the frequent manifestations of infection with *Giardia lamblia*.

The popular use of plants in the treatment of intestinal parasitoses, especially giardiasis, together with the side effects of the reference drugs and the increase in the parasite resistance, has prompted the investigation of natural products, with a view to validate the giardicidal property attributed empirically, and raise the possibility of new alternative therapies.

One of the pioneering studies on plant species with giardicidal activity was carried out in Africa by Johns et al. (1995). The authors investigated the giardicidal activity of 36 (thirty-six) plant species employed in the treatment of gastrointestinal disturbances by the population of the Luo region, in East Africa. The results showed that 21 (twenty-one) methanolic extracts obtained from the species studied brought about death or growth inhibition in trophozoites of *Giardia lamblia*. Table 1 presents the results for giardicidal activity, classified as active or inactive according to the criteria adopted by the authors, considering that the concentration of extracts and fractions tested was not related to the IC_{50}, IC_{90}, IC_{100} and/or MIC values.

Studies carried out with plant species from Cuba by Ordõnez et al. (2001) and from the USA by McAllister et al. (2001) demonstrated significant activity of *Artemisia absinthium* (IC_{50}: 200 µg/mL) and *Yucca schidigera* (IC_{50}: 15 - 250 µg/mL), respectively.

Recently, Sawangjaroen et al. (2005) reported that in Thailand patients infected with HIV and *Giardia lamblia* are known to self-medicate with plant species to treat giardiasis. The authors found that among the 12 (twelve) species tested, only 6 (six) exhibited significant giardicidal activity, with the most notable result being the efficacy of the chloroform extract of *Alpinia galanga* (IC_{50}: 37.73 µg/mL).

Aside from the scarce investigation of the giardicidal activity of extracts and fractions carried out in Africa, Brazil, China, Cuba, India, USA, Malaysia, Venezuela and Thailand, the largest contribution to this area of study has come from Mexico, where numerous plant species are used in popular medicine for the treatment of gastrointestinal illnesses, which has in turn stimulated validation studies (Calzada et al., 1998b; 1999b; 2005; 2006; Ponce-Macotela et al., 2001; Tapia-Pérez et al., 2003; Peraza-Sánchez et al., 2005).

A biological investigation reported by Ponce-Macotela et al. (1994), involving 14 (fourteen) plants used in Mexico for the treatment of diarrhoea and/or parasitic infections, demonstrated a percent inhibition of the growth of axenic strains of *Giardia lamblia* in excess of 50% for the extracts of *Castela tortuosa*, *Haematoxylon campechianum*, *Mangifera indica*, *Cupressus sempervirens*, *Punica granatum*, *Psidium guajava*, *Plantago major*, *Justicia spicigera* and *Lippia* spp. The criteria for efficacy (active or inactive) defined by the authors are expressed in the results presented in Table 1.

A study involving *Althernanthera repens*, *Boerhavia coccinea*, *Flavenia trinerva*, *Leucaena esculenta*, *Tradescantia zebrina*, *Tournefortia densiflora*, *Vitex mollis* and *Waltheria americana*; plant species used in traditional medicine in Mexico for the treatment of gastrointestinal disturbances, demonstrated that all of these species, except *Tradescantia zebrina*, possessed giardicidal activity at concentrations less than or equal to 100 µg/mL, with the greatest effect being found in assays with extracts of the *Tournefortia densiflora* seeds (Tapia-Pérez et al., 2003).

In an assessment of the giardicidal activity of extracts and fractions obtained from 6 (six) plant species used by the population of Southern Mexico, Calzada et al. (1998a) found a greater efficacy of *Rubus coriifolius*, *Cuphea pinetorum* and *Helianthemum glomeratum*, with IC_{50} values of less than 100 µg/mL.

Calzada et al. (1998b) reported a study carried out with the methanolic extracts of 19 (nineteen) plant species of Mexican origin, distributed among 13 (thirteen) families, and described potent giardicidal activity in 6 (six) species (*Acalypha phleoides*, *Cnidoscolus tehuacanensis*, *Geranium nievum*, *Hellianthella quinquenervis*, *Heliopsis longipes* and *Teloxys graveolens*), with IC_{50} values less than or equal to 20.64 µg/mL.

Plant species selected for an ethnobotanical project, carried out in conjunction with Maya communities of the Yucatan peninsula (Mexico), were extracted with polar and non-polar solvents and tested for giardicidal activity, with the results showing that all the species returned IC_{50} values of below 90 µg/mL (Ankli et al., 2002). In addition, the methanolic extracts obtained from all 10 (ten) plant species tested which are native to the Yucatan peninsula (Mexico) exhibited giardicidal activity, with IC_{50} values between 6.34 and 117.41 µg/mL; the most active species was *Tridax procumbens* (Peraza-Sánchez et al., 2005).

A recent investigation involving methanolic extracts of 26 (twenty-six) Mexican plant species found that 20 (twenty) possessed intense giardicidal activity, with IC_{50} values below 100 µg/mL, while *Dorstenia contrajerva* was the most activite with an IC_{50} of 23.3 µg/mL (Calzada et al., 2006).

In Brazil, there have been very few studies so far aimed at validating extracts and fractions with giardicidal activity. In the process of preparing this review, only 2 (two) studies were identified, carried out in Rio de Janeiro, which validated the use of *Hovenia dulcis* (IC_{50} value: 12 µg/mL for the dichloromethane fraction) (Gadelha et al., 2005) and *Mentha x piperita* (IC_{50} values: 0.8; 2.5 and 9.0 µg/mL for the methanolic, dichloromethane and hexanic extracts, respectively) (Vidal et al., 2007).

According to the data presented in Table 1, it can be concluded that 117 (one hundred and seventeen) plant species, belonging mainly to the Asteraceae, Fabaceae, Rutaceae and Verbenaceae families exhibit *in vitro* giardicidal activity, classified as strongly active and active.

There is a great diversity of flora in Brazil which is mainly concentrated in the pre-Amazon region. There is also a tradition of usage of plants for therapeutic ends in this country. The high rate of intestinal parasitoses, mainly due to *Giardia lamblia* found in the Brazilian population is a motivation for studies on the giardicidal activity of plant species which are popular and in widespread use in Brazil. Therefore, much emphasis should be given in this line of research, with a view to contributing to alternatives based on natural products to combat this disease.

Giardicidal activity of chemically defined molecules

The literature review identified 101 (one hundred and one) chemical substances isolated from diverse plant species submitted to biological study for the assessment of *in vitro* giardicidal activity. The active compounds isolated and identified belonged to the classes of flavonoids (40), especially flavanols and isoflavones, as well as triterpenes (28), with the quassinoids being the most representative, alkaloids (18), mainly indole alkaloids, sesquiterpenes (04), steroids (04), phenolic acids and esters (03), lignan (01) and amine (01). These are presented in Table 2 in alphabetical order of their chemical names, followed by the class, plant species of origin, strain tested, results and references.

The data presented in Table 2 show that diverse flavonoids isolated from different plant species exhibited giardicidal activity demonstrated in the *in vitro* assay of cytotoxicity against trophozoites of *Giardia lamblia*, with IC_{50} values varying between 0.03 and 178.7 µg/mL. Formononetin, an isoflavone isolated from *Dalbergia frutescens*, exhibited intense activity with an IC_{50} below that of metronidazole®, the reference drug for the giardiasis treatment and employed as a positive control in the assays (Khan et al., 2000). Eleven compounds, including flavonoids, steroids and triterpenes were isolated from the genus *Geranium*, represented by the species *Geranium mexicanum* and *Geranium niveum* (Calzada et al., 1999a; 2001b; 2005).

Bruceantin, (-)-epicatechin, β-sitosterol, β-sitosterol 3-*O*-β-D-glucopyranoside, hyperin, kaempferol, narcissin, quercetin and rutin are examples of compounds isolated from distinct plant species whose activity has been examined *in vitro* against different strains of *Giardia lamblia* by various authors (Gillin et al., 1982; Wright et al., 1993a; Calzada et al., 1999a; 1999b; 2001a; 2003; 2005; Calzada 2005; Arrieta et al., 2001; Alanís et al., 2003).

The great variety of chemical classes under study is indicative of diverse mechanisms of action involved in the lysis and death of *Giardia lamblia* cells, reinforcing the necessity for the development of complementary studies for the evaluation of the selectivity of the cytotoxicity of the compounds.

CONCLUSION

This literature review shows that the majority of extracts and fractions obtained from plant species employed in popular medicine for the treatment of diarrhoea and dysentery exhibit *in vitro* giardicidal activity, and these are mainly from species belonging to the Asteraceae, Fabaceae, Rutaceae and Verbenaceae families. These studies need further confirmation. The active compounds encountered so far may lead to the discovery of new drugs to combat this disiase.

ACKNOWLEDGEMENTS

The authors are grateful to the University of Illinois, Chicago, USA for permission to consult NAPRALERT, to the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) through the Programa de Qualificação Institucional (PQI) and to the Conselho Nacional de Pesquisa (CNPq) for financial support.

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Table 1. Plant extracts and fractions showing giardicidal activity *in vitro*

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
Acanthaceae	*Acanthus arboreus* Forssk.	Africa	Roots + barks	MeOH	ATCC 30957	I	Johns et al. (1995)
	Acanthus ebracteatus Vahl	Thailand	Leaves + stems	$CHCl_3$, MeOH, H_2O	Not stated	I, I, I	Sawangjaroen et al. (2005)
	Barleria lupulina Lindl.	Thailand	Leaves	$CHCl_3$, MeOH, H_2O	Not stated	I, I, I	Sawangjaroen et al. (2005)
		Thailand	Stems	$CHCl_3$, MeOH, H_2O	Not stated	I, I, I	Sawangjaroen et al. (2005)
	Justicia spicigera Schldl.	Mexico	Aerial part	MeOH	IMSS:0696:1	A	Peraza-Sánchez et al. (2005)
		Mexico	Leaves	EtOH	INP020300B2	A	Ponce-Macotela et al. (2001)
		Mexico	Leaves	EtOH	INP231087MM	SA	Ponce-Macotela et al. (2001)
		Mexico	Aerial part	Not stated	INP271087MM	A	Ponce-Macotela et al. (1994)
Agavaceae	*Yucca schidigera* Roezl.	EUA	Whole plant	n-BuOH, EtE, $CHCl_3$, AcE, n-BuOH/f	S2	SA, I, A, SA, A	McAllister et al. (2001)
Amaranthaceae	*Althernanthera repens* (L.) Kuntze	Mexico	Not stated	Hex, MeOH:H_2O	IMSS:0989:1	A, SA	Tapia-Pérez et al. (2003)
	Celosia schweinfurthiana Schinz	Africa	Whole plant	MeOH	ATCC 30957	I	Johns et al. (1995)
Anacardiaceae	*Lannea schweinfurthii* (Engl.) Engl.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
	Mangifera indica L.	Mexico	Aerial parts	Not stated	INP271087MM	A	Ponce-Macotela et al. (1994)
	Ozoroa insignis Del.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
	Rhus natalensis Krauss.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
	Schinus molle L.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
Ancistrocladaceae	*Ancistrocladus tectorius* Merr.	Malaysia	Roots	MeOH, $CHCl_3$	Not stated	I, I	Said et al. (2001)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
Annonaceae	*Annona cherimola* Miller	Mexico	Seeds	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
	Malmea depressa (Baill) R.E. Fries	Mexico	Stem bark + wood	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
Apocynaceae	*Carissa edulis* (Forsk.) Vahl	Africa	Roots + barks	MeOH	ATCC 30957	I	Johns et al. (1995)
	Catharanthus roseus G. Don	Africa	Roots	MeOH	ATCC 30957	A	Johns et al. (1995)
Arecaceae	*Cocos nucifera* L.	Mexico	Husk fiber	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
Asteraceae	*Artemisia absinthium* L.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
		Cuba	Leaves	EtOH	C-5	A	Ordóñez et al. (2001)
	Artemisia ludoviciana Nutt	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
		Mexico	Leaves	H_2O, Hex, AcE, MeOH	IMSS:0989:1	I, A, WA, WA	Said Fernández et al. (2005)
	Bidens squarrosa Less.	Mexico	Leaves	Polar extract	WB	SA	Ankli et al. (2002)
		Mexico	Aerial parts	Polar extract	WB	WA	Ankli et al. (2002)
	Centaurea dimorpha Viv.	Tunisia	Flowers + leaves	a	a	A	Damak et al. (2000)
	Centipeda minima (L.) A. Braun et Aschers	China	Aerial parts	$CHCl_3$, EtOH, MeOH, PetE,	Not stated	SA, SA, A, A	Yu et al. (1994)
	Chrysactinia mexicana A. Gray	Mexico	Aerial parts	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
	Conyza filaginoides Hieron.	Mexico	Aerial parts	MeOH:$CHCl_3$, $CHCl_3$/f, MeOH:H_2O/f, EtOAc/f	IMSS:0989:1	SA, A, SA, A	Calzada et al. (2001a)
		Mexico	Whole plant	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
	Dyssodia papposa (Vent.) Hitch	Mexico	Whole plant	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
	Eclipta prostrata (L.) L.	Thailand	Whole plant	$CHCl_3$, MeOH, H_2O	Not stated	SA, SA, I	Sawangjaroen et al. (2005)
	Flaveria trinerva (Spreng.) C. Mohr.	Mexico	Not stated	Hex, MeOH-H_2O	IMSS:0989:1	A, SA	Tapia-Pérez et al. (2003)
	Gynura pseudochina (L.) DC.	Thailand	Leaves	$CHCl_3$, MeOH, H_2O	Not stated	I, I, I	Sawangjaroen et al. (2005)
	Heliopsis longipes (Gray) Blake	Mexico	Roots	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
	Hellianthella quinquenervis (Hook.) A. Gray	Mexico	Roots	MeOH	IMSS:0989:1	SA	Calzada et al. (1998a)
	Matricaria recutita L.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
	Microglossa pyrijblia (Lam.) O. Kuntze.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
	Pluchea odorata (L.) Cass.	Mexico	Aerial parts	MeOH	IMSS:0696:1	SA	Peraza-Sánchez et al. (2005)
	Psidia arabica Jaub. et Spach	Africa	Roots	MeOH	ATCC 30957	A	Johns et al. (1995)
	Ratibida latipalearis E.L.Richards	Mexico	Roots	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
	Schkuhria pinnata (Lam.) Kuntze	Africa	Whole plant	MeOH	ATCC 30957	I	Johns et al. (1995)
	Sonchus schweinfurthii Oliver & Hiern	Africa	Leaves	MeOH	ATCC 30957	A	Johns et al. (1995)
	Spilanthes acmella (L.) Murray	Thailand	Whole plant	$CHCl_3$, MeOH, H_2O	Not stated	I, I, I	Sawangjaroen et al. (2005)
	Tridax procumbens L.	Mexico	Whole plant	MeOH	IMSS:0696:1	SA	Peraza-Sánchez et al. (2005)
	Vernonia amygdalina Del.	Africa	Leaves	MeOH	ATCC 30957	I	Johns et al. (1995)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
	Vernonia glabra Vatke	Africa	Roots	MeOH	ATCC 30957	A	Johns et al. (1995)
	Vernonia sp.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
Boraginaceae	*Tournefortia densiflora* M.Martens ex Galeotti	Mexico	Not stated	Hex, MeOH-H_2O	IMSS:0989:1	SA, SA	Tapia-Pérez et al. (2003)
Brasicaceae	*Lepidium virginicum* L.	Mexico	Whole plant	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
Burseraceae	*Commiphora africana (*A. Rich.) Engl.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
Caesalpiniaceae	*Bauhinia divaricata* L.	Mexico	Leaves	Non-polar extract	WB	SA	Ankli et al. (2002)
	Caesalpinia pulcherrima (L) Sw	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
	Cassia siamea Lam.	Africa	Roots	MeOH	ATCC 30957	A	Johns et al. (1995)
Canellaceae	*Warburgia salutaris* (Bertol.f.) Chiov.	Africa	Barks	MeOH	ATCC 30957	I	Johns et al. (1995)
Capparaceae	*Gynandropsis gynandra* Merr.	Africa	Leaves	MeOH	ATCC 30957	I	Johns et al. (1995)
Caricaceae	*Carica papaya* L.	Mexico	Seeds	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
Celastraceae	*Crossopetalum gaumeri* (Loes.) Lundell	Mexico	Leaves	Non-polar and polar extract	WB	SA, SA	Ankli et al. (2002)
Chenopidiaceae	*Chenopodium ambrosioides* L.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
	Chenopodium murale L.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
	Teloxys ambrosioides (L.) W.A.Weber	Cuba	Leaves	EtOH	C-5	WA	Ordóñez et al. (2001)
	Teloxys graveolens (Willd.) W.A.Weber	Mexico	Aerial parts	MeOH, CH_2Cl_2: MeOH/f, n-HexAc/f, Ac/f	Not stated	WA, SA, A, A	Calzada et al. (2003)
		Mexico	Whole plant	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
Cistaceae	*Helianthemum glomeratum* Lag.	Mexico	Leaves + Stems	MeOH	IMSS: 8909:1	A	Meckes et al. (1999)
		Mexico	Roots	MeOH	IMSS: 8909:1	A	Meckes et al. (1999)
		Mexico	Leaves + Stems	MeOH	IMSS:0989:1	SA	Calzada et al. (1998a)
Cochlospermaceae	*Cochlospermum angolense* (Welw)	a	a	a	a	A	Hegenscheid et al. (1992)
Commelinaceae	*Commelina erecta* L.	Mexico	Whole plant	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
	Tradescantia zebrina Hort. ex Bosse var. *zebrina*	Mexico	Not stated	Hex, MeOH-H_2O	IMSS:0989:1	WA, WA	Tapia-Pérez et al. (2003)
Convolvulaceae	*Dichondra argentea* Humb & Bonpl	Mexico	Aerial parts	MeOH	IMSS: 1090:1	WA	Calzada et al. (2006)
Cucurbitaceae	*Coccinia grandis* (L.) Voigt	Thailand	Leaves	$CHCl_3$, MeOH, H_2O	Not stated	I, I, I	Sawangjaroen et al. (2005)
Cupressaceae	*Cupressus sempervirens* L.	Mexico	Aerial parts	Not stated	INP271087-MM	A	Ponce-Macotela et al. (1994)
Ebenaceae	*Euclea divinorum* Hiern	Africa	Roots + barks	MeOH	ATCC 30957	I	Johns et al. (1995)
Euphorbiaceae	*Acalypha phleoides* Cav.	Mexico	Whole plant	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
	Cnidoscolus tehuacanensis G.L.Breckon	Mexico	Whole plant	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
	Jatropha gaumeri Greenman	Mexico	Roots	Non-polar extract	WB	I	Ankli et al. (2002)
Fabaceae	*Albizia coriaria* Oliv.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
	Cassia didymobotrya Fres.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
	Cassia occidentalis L.	Africa	Leaves	MeOH	ATCC 30957	I	Johns et al. (1995)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
	Cassia siamea Lam.	Africa	Leaves	MeOH	ATCC 30957	A	Johns et al. (1995)
	Crotalaria brevidens Benth.	Africa	Leaves	MeOH	ATCC 30957	I	Johns et al. (1995)
	Dalbergia frutescens (Vell.) Britton	Venezuela	Barks	Hex, Hex:EtOAc, EtOAc, EtOH	ATCC 30888	SA, SA, SA, SA	Khan et al. (2000)
	Diphysa carthagenesis Jacq.	Mexico	Leaves	MeOH	IMSS:0696:1	SA	Peraza-Sánchez et al. (2005)
	Gliricidia sepium (Jacq.) Kunth ex Walp.	Mexico	Leaves	MeOH	IMSS:0696:1	SA	Peraza-Sánchez et al. (2005)
	Leucaena esculenta Benth.	Mexico	Not stated	Hex, MeOH-H_2O	IMSS:0989:1	A, SA	Tapia-Pérez et al. (2003)
	Ormocarpum trichocarpurn (Taub.) Engl.	Africa	Roots+ barks	MeOH	ATCC 30957	I	Johns et al. (1995)
Geraniaceae	*Geranium mexicanum* H. B. K.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	WA	Calzada et al. (2006)
		Mexico	Roots	CH_2Cl_2: MeOH, EtOAc/f, H_2O /f	IMSS:0989:1	SA, SA, A	Calzada (2005)
	Geranium niveum S. Watson	Mexico	Roots	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
		Mexico	Roots	$CHCl_3$/f, H_2O /f, EtOAc/f	Not stated	A, SA, SA	Calzada et al. (1999a)
Gesneriaceae	*Kohleria deppeana* L.	Mexico	Leaves	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
Hippocrateaceae	*Hippocratea excelsa* H. B. K.	Mexico	Roots	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
Lamiaceae	*Thymus vulgaris* L.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
	Coleus kilimandschari Gürke ex Engl.	Africa	Leaves	MeOH	ATCC 30957	A	Johns et al. (1995)
	Leonotis nepetifolia (L.)R. Br.	Africa	Roots	MeOH	ATCC 30957	I	Johns et al. (1995)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
	Mentha x piperita Lin.	Brazil	Leaves	MeOH, CH_2Cl_2/f, RFMeOH, CH_2Cl_2, Hex, Inf	ATCC:30888	SA, SA, SA, SA, SA, A	Vidal et al. (2007)
	Ocimum basilicum L.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
	Ocimum suave L.	Africa	Leaves	MeOH	ATCC 30957	A	Johns et al. (1995)
	Lavandula angustifolia Mill.	Australian	Essential oils	Not stated	Not stated	A	Moon et al. (2006)
	Lavandula intermedia Emeric ex Loisel	Australian	Essential oils	Not stated	Not stated	A	Moon et al. (2006)
Lauraceae	*Persea americana* Mill.	Mexico	Seeds	Not stated	INP271087-MM	I	Ponce-Macotela et al. (1994)
Leguminosae	*Haematoxylon campechianum* L.	Mexico	Aerial parts	Not stated	INP271087-MM	A	Ponce-Macotela et al. (1994)
	Senna villosa Mills	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
Liliaceae	*Allium sativum* L.	Mexico	Epidermis of bulbs	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
		a	a	a	a	A	Soffar; Mokhtar (1991)
		UK	Bulb	Not stated	ATCC 30888	SA	Harris et al. (2000)
	Aloe sp.	Africa	Roots	MeOH	ATCC 30957	I	Johns et al. (1995)
Loganiaceae	*Spigelia anthelmia* L.	Mexico	Whole plant	MeOH	IMSS:0696:1	A	Peraza-Sánchez et al. (2005)
Lythraceae	*Cuphea pinetrotum* Benth.	Mexico	Roots	MeOH, CH_2Cl_2, $CHCl_3$/f, EtOAc/f,H_2O/res	IMSS:0989:1	SA, SA, A, SA, WA	Calzada et al. (1998a)
Malpighiaceae	*Byrsonima crassifolia* (L.) Kunth	Mexico	Leaves	MeOH	IMSS:0696:1	SA	Peraza-Sánchez et al. (2005)
Meliaceae	*Melia azedarach* L.	Africa	Leaves	MeOH	ATCC 30957	I	Johns et al. (1995)
	Swietnia humilis Zuccarini	Mexico	Seeds	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
Mimosaceae	*Prosopis juliflora* (Sw.) D.C.	Mexico	Aerial parts	Not stated	INP271087-MM	I	Ponce-Macotela et al. (1994)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
Moraceae	*Dorstenia contrajerva* L.	Mexico	Rhizome	Non-polar and polar extract	WB	I, I	Ankli et al. (2002)
		Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
		Mexico	Whole plant	MeOH	IMSS:0696:1	SA	Peraza-Sánchez et al. (2005)
Myrsinaceae	*Parathesis chiapensis* Fernald	Mexico	Stems + leaves	MeOH	IMSS:0989:1	I	Calzada et al. (1998a)
Myrtaceae	*Psidium guajava* L.	Mexico	Aerial parts	Not stated	INP271087-MM	A	Ponce-Macotela et al. (1994)
	Psidium sartorianum (Berg) Nied.	Mexico	Leaves	Non-polar and polar extract	WB	SA, SA	Ankli et al. (2002)
Nyctaginaceae	*Boerhavia coccinea* Mill.	Mexico	Not stated	Hex, MeOH-H_2O	IMSS:0989:1	SA, SA	Tapia-Pérez et al. (2003)
Onagraceae	*Fuchsia microphylla* H.B.& K.	Mexico	Stems + leaves	MeOH	IMSS:0989:1	I	Calzada et al. (1998a)
Olacaceae	*Ximenia caffra* Sond.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
Papaveraceae	*Bocconia frutescens* L.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
Papilionaceae	*Piscidia piscipula* (L.) Sarg.	Mexico	Leaves	Non-polar and polar extract	WB	SA, SA	Ankli et al. (2002)
Piperaceae	*Piper betle* L.	Thailand	Leaves	$CHCl_3$, MeOH, H_2O	Not stated	SA, I, I	Sawangjaroen et al. (2005)
	Piper chaba Hunter	Thailand	Fruits	$CHCl_3$, MeOH, H_2O	Not stated	SA, I, I	Sawangjaroen et al. (2005)
	Piper longum Linn.	India	Fruits	H_2O, EtOH, n-BuOH/f, $CHCl_3$/f, Hex/f	Not stated	A, A, I, I, I	Tripathi et al. (1999)
Plantaginaceae	*Plantago major* L.	Mexico	Aerial parts	Not stated	INP271087-MM	A	Ponce-Macotela et al. (1994)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
Plumbaginaceae	*Plumbago scandens* L.	Mexico	Stem barks	MeOH	IMSS:0989:1	SA	Calzada et al. (1998a)
Poaceae	*Oriza sativa* L.	Mexico	Aerial parts	Not stated	INP271087-MM	I	Ponce-Macotela et al. (1994)
Polypodiaceae	*Microgramma nitida* (J. Sm.) A. Reed Sm.	Mexico	Fruits and Whole plant	Polar extract	WB	I, I	Ankli et al. (2002)
Punicaceae	*Punica granatum* L.	Mexico	Exocarpo of fruits	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
		Mexico	Aerial parts	Not stated	INP271087-MM	A	Ponce-Macotela et al. (1994)
Ranunculaceae	*Clematis dioica* L.	Mexico	Leaves	MeOH	IMSS:0989:1	I	Calzada et al. (1998a)
	Coptis teeta Wall	Burma	Roots	H_2O, MeOH, $CHCl_3$, i-prOH	Portland I	I, A, A, A	Kaneda et al. (1990)
Rhamnaceae	*Hovenia dulcis* Thunb.	Brazil	Leaves	MeOH, CH_2Cl_2/f, Hex/f, EtOAc/f	P1	SA, SA, SA, SA	Gadelha et al. (2005)
Rhizophoraceae	*Rizophora mangle* L.	Mexico	Aerial parts	Not stated	INP271087-MM	I	Ponce-Macotela et al. (1994)
Rosaceae	*Rubus coriifolius* Focke	Mexico	Aerial parts	CH_2Cl_2:MeOH, n-Hex/f, $CHCl_3$/f, EtOAc/f, H_20/res	IMSS:0989:1	SA, A, A, WA, SA	Alanís et al. (2003)
		Mexico	Stems + leaves	MeOH	IMSS:0989:1	SA	Calzada et al. (1998a)
Rubiaceae	*Cigarrilla mexicana* (DC.) Aiello	Mexico	Leaves	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
Rutaceae	*Casimiroa tetrameria* Millsp.	Mexico	Leaves	Non-polar extract	WB	SA	Ankli et al. (2002)
	Murraya paniculata (L.) Jack	Thailand	Leaves	$CHCl_3$, MeOH, H_2O	Not stated	A, I, I	Sawangjaroen et al. (2005)
	Ptelea trifoliata L.	Mexico	Stem barks + wood	MeOH	IMSS:0989:1	SA	Calzada et al. (1998b)
	Ruta chalepensis L.	Mexico	Aerial parts	MeOH	IMSS:1090:1	SA	Calzada et al. (2006)
	Toddalia asiatica (L.) Lam.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
	Zanthoxylum liebmannianum (Engl.) P. Wilson	Mexico	Leaves	EtOH	IMSS:0989:1	SA	Arrieta et al. (2001)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
	Zanthoxylurn chalybeurn Engl.	Africa	Roots + barks	MeOH	ATCC 30957	I	Johns et al. (1995)
Sapindaceae	*Cupania dentata* DC.	Mexico	Barks	MeOH	IMSS:0696:1	SA	Peraza-Sánchez et al. (2005)
Sapotaceae	*Chrysophyllum mexicanum* Brandegee	Mexico	Roots	Polar extract	WB	I	Ankli et al. (2002)
Schizaeaceae	*Lygodium venustum* Sw	Mexico	Aerial parts	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
Simaroubaceae	*Castela texana* (T.&G.) Rose	Mexico	Stem bark + wood	MeOH	IMSS:0989:1	A	Calzada et al. (1998b)
	Castela tortuosa Liemb.	Mexico	Stem barks + wood	MeOH	IMSS:0989:1	A	Calzada et al. (1998b)
		Mexico	Aerial parts	Not stated	INP271087-MM	A	Ponce-Macotela et al. (1994)
	Harrisonia abyssinica Oliv.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
Solanaceae	*Capsicum annum* L.	Mexico	Aerial parts	Not stated	INP271087-MM	I	Ponce-Macotela et al. (1994)
	Solanum incanum L.	Africa	Roots + barks	MeOH	ATCC 30957	A	Johns et al. (1995)
	Solanum nigrum L.	Africa	Leaves	MeOH	ATCC 30957	A	Johns et al. (1995)
Sterculicaceae	*Chiranthodendron pentadactylon* Larreat	Mexico	Flowers	MeOH	IMSS: 1090:1	SA	Calzada et al. (2006)
	Waltheria americana L.	Mexico	Not stated	Hex, MeOH-H_2O	IMSS:0989:1	A, WA	Tapia-Pérez et al. (2003)
Tiliaceae	*Triumfetta semitriloba* Jacq.	Mexico	Leaves	MeOH	IMSS:0696:1	SA	Peraza-Sánchez et al. (2005)
Verbenaceae	*Aloysia triphylla* (L'Hér) Britton	Mexico	Aerial parts	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
	Lippia alba (Mill.) N. E. Br.	Mexico	Aerial parts	MeOH	IMSS: 1090:1	A	Calzada et al. (2006)
	Lippia berlandieri Shauer	Mexico	Aerial parts	Not stated	INP271087-MM	A	Ponce-Macotela et al. (1994)

Family	Botanical name	Origin	Part used	Preparation	*Giardia lamblia* strain	Result	References
	Lippia spp.	Not stated	Leaves	EtOH	INP231087MM	A	Ponce-Macotela et al. (2006)
		Not stated	Leaves	EtOH	INP020300B2	SA	Ponce-Macotela et al. (2006)
	Stachitarpheta jamaicensis (L.) Vahl.	Cuba	Leaves	EtOH	C-5	I	Ordóñez et al. (2001)
	Vitex mollis Kunth.	Mexico	Not stated	Hex, MeOH-H_2O	IMSS:0989:1	WA, SA	Tapia-Pérez et al. (2003)
Vitaceae	*Rhoicissus revoilii* Planch.	Africa	Tuber	MeOH	ATCC 30957	I	Johns et al. (1995)
Zingiberaceae	*Alpinia galanga* (L.) Willd.	Thailand	Rhizome	$CHCl_3$, MeOH, H_2O	Not stated	SA, I, I	Sawangjaroen et al. (2005)
	Boesenbergia pandurata (Roxb.) Schltr.	Thailand	Rhizome	$CHCl_3$, MeOH, H_2O	Not stated	SA, SA, I	Sawangjaroen et al. (2005)
	Zingiber zerumbet (L.) Roscoe ex Sm.	Thailand	Rhizome	$CHCl_3$, MeOH, H_2O	Not stated	SA, I, I	Sawangjaroen et al. (2005)

[a] Date incomplete derived from an abstract

AcE: Acetone extract; H_2O: Aqueous extract; n-BuOH: n-Butanol extract; $CHCl_3$: Chloroform extract; CH_2Cl_2: Dichloromethane extract; EtOH: Ethanol extract; EtOAc: Ethyl acetate extract; EtE: ethyl ether extract; Hex: Hexane extract; Hex:EtOAc: Hexane-Ethyl acetate extract; i-prOH: Isopropanol extract; MeOH: Methanol extract; MeOH:$CHCl_3$: Methanol-chloroform extract; MeOH-H_2O: Methanol-water extract; PetEE: Petroleum ether extract; n-BuOH/f: n-Butanol insoluble fraction; RFMeOH: Residual fraction of methanol extract; Ac/f: Acetone fraction; $CHCl_3$/f: Chloroform fraction; CH_2Cl_2/f: Dichloromethane fraction; CH_2Cl_2:MeOH/f: Dichloromethane-methanol fraction; EtOAc/f: Ethyl acetate fraction; Hex/f: Hexane fraction; Inf: Infusion; MeOH:H_2O/f: Methanol-water fraction; n-BuOH/f: n-Butanol fraction; n-HexAc/f: n-Hexane acetone fraction; n-Hex/f: n-Hexane fraction; H_2O/res: water residual

IC_{50} : Inhibitory Concentration 50%

SA: strongly active ($IC_{50} \leq 100$ µg/mL); A: active ($100 < IC_{50} \leq 250$ µg/mL); WA: weakly active ($250 < IC_{50} \leq 500$ µg/mL); I: inactive ($IC_{50} \geq 500$ µg/mL)

Table 2. Chemically defined natural compounds showing giardicidal activity *in vitro*

Chemical substance	Class	Source	*Giardia lamblia* strain	Result	References
Ailanthinone	Triterpene	*Simarouba amara*	VNB1	IC_{50}: 45.44 μM	Wright et al. (1993a)
Ailanthone	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Apigenin-7-*O*-β-D-glucopyranoside	Flavonoid	*Cuphea pinetorum*	IMSS:0989:1	IC_{50} : 48.8 g/mL	Calzada (2005)
Asarinin	Lignan	*Zanthoxylum liebmannianum*	IMSS:0989:1	IC_{50} : 35.45 μg/mL	Arrieta et al. (2001)
Astragalin	Flavonoid	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 47.5 μg/mL	Calzada et al. (2001a)
Berberine	Alkaloid	a	a	Inactive	Kaneda et al. (1990)
Biochanin A	Flavonoid	*Dalbergia frutescens*	ATCC 30888	IC_{50} : 3.50 μg/mL	Khan et al. (2000)
Brevilin A	Sesquiterpene lactone	*Centipeda minima*	Not stated	IC_{50} : 5.57μg/mL	Yu et al. (1994)
Bruceantin	Triterpene	*Brucea javanica*	VNB1	IC_{50}: 1.20 μM	Wright et al. (1993a)
		Brucea antidysenterica	Not stated	Inactive	Gillin et al. (1982)
Bruceantinol	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Brucein A	Triterpene	*Brucea javanica*	VNB1	IC_{50}: 8.84 μM	Wright et al. (1993a)
Brucein B	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Brucein C	Triterpene	*Brucea javanica*	VNB1	IC_{50} > 44 μM	Wright et al. (1993a)
Brucein D	Triterpene	*Brucea javanica*	VNB1	IC_{50} > 49 μM	Wright et al. (1993a)
Brusatol	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
		Brucea javanica	VNB1	IC_{50}: 6.17 μM	Wright et al. (1993a)
Castanin	Flavonoid	*Dalbergia frutescens*	ATCC 30888	IC_{50} >5.0 μg/mL	Khan et al. (2000)

Chemical substance	Class	Source	*Giardia lamblia* strain	Result	References
(+)-Catechin	Flavonoid	*Geranium mexicanum*	IMSS:0989:1	IC_{50}:33.9 μg/mL	Calzada et al (2005)
		Rubus coriifolius	IMSS:0989:1	IC_{50} : 34.0 μg/mL	Alanís et al. (2003)
β-Caryophyllene-4,5-α-oxide	Sesquiterpene	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 53.8 μg/mL	Calzada et al. (2001a)
3-β-Caffeoyl-12-oleanen-28-oic acid	Triterpene	*Geranium niveum*	Not stated	IC_{50}: 31.2 μg/mL	Calzada et al. (1999a)
Chaparrin	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Chaparrinone, 6-alpha-senecioyl-oxy	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Chrysin	Flavonoid	*Teloxys graveolens*	Not stated	IC_{50} : 109.4 μg/mL	Calzada et al. (2003)
Corialstonidine	Alkaloid	a	a	Inactive	Wright et al. (1993b)
Corialstonine	Alkaloid	a	a	Inactive	Wright et al. (1993b)
Cuneatin	Flavonoid	*Dalbergia frutescens*	ATCC 30888	Inactive	Khan et al. (2000)
Daidzein	Flavonoid	*Dalbergia frutescens*	ATCC 30888	IC_{50} : 3.75 μg/mL	Khan et al. (2000)
3',4'-Dihydrousambarensine	Alkaloid	*Strychnos usambarensis*	Not stated	IC_{50} : 5.14 μg/mL	Wright et al. (1994)
7,3-Dihydroxy-4-methoxyisoflavone	Flavonoid	*Machaerium aristulatum*	ATCC: 30888	IC_{50} : 1.9 μg/mL	El-Sohly et al. (1999)
7-Hydroxy-4'-methoxyisoflavone	Flavonoid	*Machaerium aristulatum*	ATCC: 30888	IC_{50} : 0.28 μg/mL	El-Sohly et al. (1999)
3,6-Dimethoxykaempferol	Flavonoid	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 65.40 μg/mL	Calzada et al. (1999b)
Echitamine	Alkaloid	a	a	Inactive	Wright et al. (1993b)
Ellagic acid	Phenolic acid	*Rubus coriifolius*	IMSS:0989:1	IC_{50} : 24.9 μg/mL	Alanís et al. (2003)
(-)-Epicatechin	Flavonoid	*Rubus coriifolius*	IMSS:0989:1	IC_{50} : 1.6μg/mL	Alanís et al. (2003)
		Geranium mexicanum	IMSS:0989:1	IC_{50} : 1.6 μg/mL	Calzada et al. (2005)

Chemical substance	Class	Source	*Giardia lamblia* strain	Result	References
(-)-Epigallocatechin	Flavonoid	*Helianthemum glomeratum*	IMSS: 8909:1	IC_{50} : 8.06 μg/mL	Meckes et al. (1999)
(-)-Epigallocatechin gallate	Flavonoid	*Helianthemum glomeratum*	IMSS: 8909:1	IC_{50} : 88.83 μg/mL	Meckes et al. (1999)
Erythrodiol	Triterpene	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 29.9 μg/mL	Calzada et al. (2001a)
Flavopereirine, 5-6-dihydro	Alkaloid	*Strychnos usambarensis*	Not stated	Inactive	Wright et al. (1994)
Formononetin	Flavonoid	*Dalbergia frutescens*	ATCC 30888	IC_{50} : 0.03 μg/mL	Khan et al. (2000)
Fujikinetin	Flavonoid	*Dalbergia frutescens*	ATCC 30888	IC_{50} : 1.5 μg/mL	Khan et al. (2000)
Gallic acid	Phenolic acid	*Rubus coriifolius*	IMSS:0989:1	IC_{50} : 70.3μg/mL	Alanís et al. (2003)
Genistein	Flavonoid	*Dalbergia frutescens*	ATCC 30888	$IC_{50} > 5.0$μg/mL	Khan et al. (2000)
Geranin A	Flavonoid	*Geranium niveum*	Not stated	IC_{50} : 2.4 μg/mL	Calzada et al. (1999a)
Geranin B	Flavonoid	*Geranium niveum*	Not stated	IC_{50} : 6.0 μg/mL	Calzada et al. (1999a)
Geranin C	Flavonoid	*Geranium niveum*	a	Active	Calzada et al. (2001b)
Geranin D	Flavonoid	*Geranium niveum*	a	Active	Calzada et al. (2001b)
Glaucarubin	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Glaucarubinone	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
		Simarouba amara	VNB1	IC_{50}: 12.42 μM	Wright et al. (1993a)
Glaucarubol	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Glaucarubolone	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Glycitein	Flavonoid	*Dalbergia frutescens*	ATCC 30888	Inactive	Khan et al. (2000)

Chemical substance	Class	Source	*Giardia lamblia* strain	Result	References
Holacanthone	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Hyperin	Flavonoid	*Geranium niveum*	Not stated	IC_{50}: 85.1 μg/mL	Calzada et al. (1999a)
		Zanthoxylum liebmannianum	IMSS:0989:1	IC_{50} :49.20 μg/mL	Arrieta et al. (2001)
		Rubus coriifolius	IMSS:0989:1	IC_{50} : 49.2 μg/mL	Alanís et al. (2003)
Isoquercitrin	Flavonoid	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 87.3 μg/mL	Calzada et al. (2001a)
Isorhamnetin 3-*O*-(6′′-*O*-*E*-caffeoyl)-β-D-galactopyranoside	Flavonoid	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 15.3 μg/mL	Calzada et al. (2001a)
Kaempferol	Flavonoid	*Helianthemum glomeratum*	IMSS:0989:1	IC_{50} : 8.73 μg/mL	Calzada et al. (1999b)
		Cuphea pinetorum Benth.	IMSS:0989:1	IC_{50} : 8.7 μg/mL	Calzada (2005)
Kaempferol 3-*O*-(6′′-*O*-*E*-caffeoyl)-β-D-galactopyranoside	Flavonoid	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 47.0 μg/mL	Calzada et al. (2001a)
Luteolin-7-*O*-β-D-glucopyranoside	Flavonoid	*Cuphea pinetorum*	IMSS:0989:1	IC_{50}: 42.1 μg/mL	Calzada (2005)
Melilotoside	Phenol glycoside	*Teloxys graveolens*	Not stated	IC_{50} : 16.8μg/mL	Calzada et al. (2003)
Methyl gallate	Phenolic ester	*Geranium niveum*	Not stated	IC_{50} : 49.2 μg/mL	Calzada et al. (1999a)
Narcissin	Flavonoid	*Teloxys graveolens*	Not stated	IC_{50} : 94.6μg/mL	Calzada et al. (2003)
		Conyza filaginoides	IMSS:0989:1	IC_{50} : 94.7 μg/mL	Calzada et al. (2001a)
Neurolenin B	Sesquiterpene lactone	*Neurolaena oaxacana*	Not stated	MIC: 3.80μM	Passreiter et al. (1999)
Neurolenin C + D	Sesquiterpene lactone	*Neurolaena oaxacana*	Not stated	MIC: 8.40μM	Passreiter et al. (1999)
Nicotiflorin	Flavonoid	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 22.5 μg/mL	Calzada et al. (2001a)
Nigaichigoside	Triterpene	*Rubus coriifolius*	IMSS:0989:1	IC_{50} : 123.6μg/mL	Alanís et al. (2003)

Chemical substance	Class	Source	*Giardia lamblia* strain	Result	References
Nigakilactone A	Triterpene	a	a	Equivocal	Dou et al. (1996)
Odoratin	Flavonoid	*Dalbergia frutescens*	ATCC 30888	Inactive	Khan et al. (2000)
Paraine	Triterpene	a	a	Equivocal	Dou et al. (1996)
Pinocembrin	Flavonoid	*Teloxys graveolens*	IMSS:0989:1	IC_{50} : 57.39μg/mL	Calzada et al. (1999b)
		Teloxys graveolens	Not stated	IC_{50} : 57.4μg/mL	Calzada et al. (2003)
Pinostrobin	Flavonoid	*Teloxys graveolens*	IMSS:0989:1	IC_{50} : 80.76μg/mL	Calzada et al. (1999b)
		Teloxys graveolens	Not stated	IC_{50} : 80.8μg/mL	Calzada et al. (2003)
Piperine	Alkaloid	*Piper longum*	Not stated	Inactive	Tripathi et al. (1999)
Pseudobaptogenin	Flavonoid	*Dalbergia frutescens*	ATCC 30888	IC_{50} : 0.56 μg/mL	Khan et al. (2000)
Quassialactol	Triterpene	a	a	Equivocal	Dou et al. (1996)
Quassin	Triterpene	a	a	Equivocal	Dou et al. (1996)
Quassin, neo	Triterpene	a	a	Equivocal	Dou et al. (1996)
Quassin,18-hydroxy	Triterpene	a	a	Equivocal	Dou et al. (1996)
Quercetin	Flavonoid	*Helianthemum glomeratum*	IMSS:0989:1	IC_{50} : 26.47 μg/mL	Calzada et al. (1999b)
		Cuphea pinetorum	IMSS:0989:1	IC_{50} : 26.5 μg/mL	Calzada (2005)
Quercetin-3-*O*-α-rhamnopyranoside	Flavonoid	*Cuphea pinetorum*	IMSS:0989:1	IC_{50}: 92.1μg/mL	Calzada (2005)
Quercetin 3-*O*-(6″-*O*-*E*-caffeoyl)-β-D-glucopyranoside	Flavonoid	*Conyza filaginoides*	IMSS:0989:1	IC_{50} : 104.9 μg/mL	Calzada et al. (2001a)

Chemical substance	Class	Source	*Giardia lamblia* strain	Result	References
Retulinal	Alkaloid	*Strychnos variabilis*	Not stated	Inactive	Wright et al. (1994)
Retulinal, iso	Alkaloid	*Strychnos variabilis*	Not stated	Inactive	Wright et al. (1994)
Rutin	Flavonoid	*Teloxys graveolens*	Not stated	IC_{50} : 178.7μg/mL	Calzada et al. (2003)
		Conyza filaginoides	IMSS:0989:1	IC_{50} : 178.7 μg/mL	Calzada et al. (2001a)
Samaderin E	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Simalikalactone D	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Squalen	Steroid	*Cuphea pinetorum*	IMSS:0989:1	IC_{50} :99.1 μg/mL	Calzada (2005)
β-Sitosterol	Steroid	*Zanthoxylum liebmannianum*	IMSS:0989:1	IC_{50} :71.01 μg/mL	Arrieta et al. (2001)
		Cuphea pinetorum	IMSS:0989:1	IC_{50} : 71.1μg/mL	Calzada (2005)
β-Sitosterol 3-*O*-β-D-glucopyranoside	Steroid	*Geranium mexicanum*	IMSS:0989:1	IC_{50} : 61.5 μg/mL	Calzada et al (2005)
		Rubus coriifolius	IMSS:0989:1	IC_{50} : 61.5 μg/mL	Alanís et al. (2003)
β-Sitosterol glucoside	Steroid	*Zanthoxylum liebmannianum*	IMSS:0989:1	IC_{50}: 61.50 μg/mL	Arrieta et al. (2001)
Strychnobiline	Alkaloid	*Strychnos variabilis*	Not stated	Inactive	Wright et al. (1994)
Strychnobiline, beta	Alkaloid	*Strychnos variabilis*	Not stated	Inactive	Wright et al. (1994)
Strychnobiline, iso	Alkaloid	*Strychnos variabilis*	Not stated	Inactive	Wright et al. (1994)
Strychnobiline, iso: 12'-hydroxy	Alkaloid	*Strychnos variabilis*	Not stated	Inactive	Wright et al. (1994)
Strychnopentamine	Alkaloid	*Strychnos variabilis*	Not stated	IC_{50} : 7.30μM	Wright et al. (1994)

Chemical substance	Class	Source	*Giardia lamblia* strain	Result	References
Strychnopentamine, iso	Alkaloid	*Strychnos variabilis*	Not stated	IC_{50} : 10.9µM	Wright et al. (1994)
Tiliroside	Flavonoid	*Helianthemum glomeratum*	IMSS:0989:1	IC_{50} : 17.36 µg/mL	Calzada et al. (1999b)
Tyramine	Amine	*Geranium mexicanum*	IMSS:0989:1	IC_{50} :68.9 µg/mL	Calzada et al (2005)
Undulatone	Triterpene	*Brucea antidysenterica*	Not stated	Inactive	Gillin et al. (1982)
Usambarensine	Alkaloid	*Strychnos usambarensis*	Not stated	IC_{50} : 3.89µM	Wright et al. (1994)
Usambarensine,3'-4'-dihydro	Alkaloid	*Strychnos usambarensis*	Not stated	IC_{50} : 5.14µM	Wright et al. (1994)
Usambarine	Alkaloid	*Strychnos usambarensis*	Not stated	IC_{50} : 22.3µM	Wright et al. (1994)
Xanthomicrol	Flavonoid	*Brickellia paniculata*	IMSS:0989:1	IC_{50} : 77.96µg/mL	Calzada et al. (1999b)

[a] Date incomplete derived from an abstract