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Potential of Panamanian aromatic flora as a source of novel essential oils

Abstract

Background: Flora of Panama is one of the richest in the world and occupies fourth place in vascular plant diversity in the American content. Many plants of the families interalia Apiaceae, Asteraceae, Lauraceae, Lamiaceae, Myrtaceae, Piperaceae, Rutaceae, Rosaceae and Sapindaceae have yielded essential oils (EOs). A summary of results on chemical composition and biological activities of 20 EOs from selected Panamanian plants is provided here, which shows the potential of aromatic flora of Panama. Six species of *Piper* had sesquiterpene hydrocarbons as major components, three were characterized by monoterpene hydrocarbons, and one by a phenylpropanoid, dillapiole. EOs of *P. hispidum* and *P. longipsicum* at a concentration of 250µg/ml showed larvicidal activity against *Aedes aegypti*, while *P. multiplinervium* against *Helicobacter pylori* (IC_{50} = 0.1µg/mL). The main components of EOs from 9 species belonging to 4 genera: *Eugenia*, *Calyptranthes*, *Eugenia*, *Plinia*, and *Myrcia* were sesquiterpene hydrocarbons (*E*-caryophyllene) or oxygenated sesquiterpenes (α-bisabolol). EO of *E. acapulensis* showed strong antimicrobial activity against *Staphylococcus aureus* (MIC=125µg/mL) and *Mycobacteria smegmatis* (MIC=250µg/mL).

Keywords: aromatic flora, Panama, essential oils, biological activities, *Myrtaceae*, *Piperaceae*

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Introduction

Essential oils are widely distributed in nature and are found in conifers, Myrtaceae, Rutaceae, Lamiaceae, Umbeliferae, Asteraceae, Rosaceae, Lauraceae, among others. Approximately 100 species are known to be the source of essential oils in the world, but there are more than 2000 species of plants distributed in more them 60 families, which are potential sources of novel essential oils. Approximately 300 essential oils out of an estimated number of 3000 are commercially important in the world. Currently, the world production and use of essential oils is increasing rapidly. It is estimated that world production of essential oils varies from 40,000 to 60,000 tons per year, with a market value of US$700 million. The countries which dominate the market are Brazil, China, U.S.A., Indonesia, India and Mexico, however the main consumers are the U.S.A. European Union and Japan.[1] Essentials oils find diverse uses in food industry, perfumery and cosmetics, aromatherapy, and pharmaceutical industry.[2] Many essential oils are used as antiseptic, flavoring agents, expectorants, carminatives, eupeptics, antispasmodics and analgesics, among others. Ethnobotanical and chemical components from most prevalent species of *Piper* from Panama have been recently reviewed by our group.[3] This minireview aims to provide summarized information on the chemistry and biological activities of EOs from most prevalent aromatic species in the Panamanian Flora studied in our Center.

Methodology

For this minireview, the data were collected from our published and unpublished work on the Panamanian Aromatic Flora. In addition, literature search on Panamanian species was carried out using different databases.

Aromatic flora of panama

The Table 1 shows important plants families, with number of genera, species, including endemic which are of potential importance as a source of novel essential oils.[2]

Table 1 Families, Genera, Species represented in Panama[a]

Family	No of genera	No of especies	No. of endemic species	Principal genera
Apiaceae	12	22	1	*Hydrocotyle* (6) *Myrrhidendron* (3)
Asteraceae	137	303	39	*Mikania* (18) Neomirandea (14)
Chlorantaceae	1	9	2	*Hedyosmum* (9)
Lamiaceae	10	50	3	*Hyptis* (20) *Salvia* (11)
Lauraceae	13	107	10	*Ocotea* (45) *Nectandra* (17)
Myricaceae	1	1	-	*Morella* (1)
Myrtaceae	17	72	6	*Eugenia* (26) *Myrcia* (6)
Piperaceae	5	242	50	*Piper* (139) *Peperomia* (100)
Rosaceae	10	19	3	*Rubus* (5)
Rutaceae	15	38	4	*Zanthoxylum* (13) *Citrus* (6)
Sapindaceae	16	94	17	*Paulina* (39) *Serjania* (16)
Zygophyllaceae	2	5	-	*Kalistroemia* (3)

[a]value in parenthesis indicates number of species

Chemical composition of essential oils of selected species

Over the last 20 years, we have studied chemical composition of 37 essential oils and evaluated biological activity of 18. The chemical composition of essential oils was analyzed by a combination of GC-FID and GC-MS procedures using capillary columns with HP-5MS, methylsilicone SE-30, Carbowax. Identification of components was achieved by means of their GC retention indices, determined in relation to Kovat indices, and by comparison of fragmentation patterns in the mass spectra with those stored in our own library, in the GC-MS database and with literature data (Adams, NIST, Wiley).[4] Quantification of each compound was performed on the basis of their GC peak areas. Plants were collected from different places in Panama, their taxonomic identification was established by Alex Espinosa and Carlos Guerra. The essential oil was obtained by hydrodistillation using Cleavenger type apparatus described in the European Pharmacopoeia (Table 2).[5]

Biological activity of essential oils studied

Antimicrobial, antifungal, larvicidal, anti- *Helicobacter pylori* activities were evaluated according to the published protocols (Table 3).[14,2]

Table 2 Chemical composition of different essential oils studied

Family	Species	Plant part	Main components	Reference
Lamiaceae	*Ocimm basilicum* L.	Leaves	methyl eugenol (78,7%)	Santana et al.[6]
	(FLORPAN 8366)		germacrene D (3,1%)	
Lauraceae	*Protium confusum* (Rose) Pittier	Leaves	spathulenol (19,3%)	Santana et al.[7]
	(FLORPAN 2932)		*β*-caryophyllene oxide (14,1%)	
			β-caryophyllene (8,0%)	
		Fruits	limonene (60,2%)	Santana et al.[7]
		Bark	*p*-cymen-8-ol (14,4%)	Santana et al.[7]
			spathulenol (9,5%)	
			hexadecanoic acid (8,4%)	
		Stem	*p*-cymen-8-ol (6,1%)	Santana et al.[7]
			spathulenol (9,0%)	
			hexadecanoic acid (7,8%)	
Monimiaceae	*Siparuna thecaphora*	Leaves	spathulenol (9,4%)	Vila et al.[8]
	(Poepp). Et Endl.) A.DC.		*α*-copaene (4,5%)	
			α-cadinol (3,6%)	
Myrtaceae	*Calycolpus warszewiczianus* O. Berg	Leaves	*E*-caryophyllene (24,3%)	Santana et al.[9]
	(FLORPAN 8353)		*β*-selinene (16,8%)	
			α-selinene (14,7%)	
			δ-amorphene (5,2%)	
	Calyptranthes hylobates Standl. Ex. Amshoff	Leaves	carotol (29,8 %)	Santana et al.[10]
	(FLORPAN 8852)		elemicine (23,7 %)	
			myristicin (18,0 %)	
			α-selinene (5,4 %)	
			β-(*E*)-farnesene (4,7 %)	
	Calyptranthes microphylla B. Holts & M.L.	Leaves	*α*-pinene (48,4%)	Santana et al.[11]
	(FLORPAN 8843)		*β*-bisabolene (12,0%)	
			β-pinene (4,5%)	
			trans-caryophyllene (3,4%)	
			cis-pinocarveol (3,7%)	
	Eugenia acapulcensis Steud	Leaves	cadinol (4,2%)	Vila et al.[12]
	(FLORPAN 2630)		spathulenol (4,2%)	
			trans-pinocarveol (4,2%)	

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Table Continued

Family	Species	Plant part	Main components	Reference
			δ-cadinene (3,8%)	
			(*Z*)-nerolidol (3,5%)	
	Eugenia octopleura	Leaves	*α*-pinene (43,1%)	Santana et al.[11]
	Krug & Urb		limonene (23,6%)	
	(FLORPAN 8548)		*β*-ocimene (5,5%)	
			viridiflorol (3,6%)	
			linalool (3,0%)	
	Eugenia principium Mac Vaugh	Leaves	*E*-caryophyllene (12,7%)	Santana et al.[9]
	(FLORPAN 8362)		valerianol (6,9%)	
			10-*epi*-*γ*-eudesmol (5,6%)	
	Eugenia venezuelensis O. Berg	Leaves	*α*-pinene (24,5%)	Santana et al.[9]
	(FLORPAN 8359)		*β*-pinene (27,4%)	
			germacrene B (8,7%)	
	Myrcia aff fosteri Croat	Leaves	*α*-bisabolol (19,2%)	Santana et al.[11]
	(FLORPAN 8544)		*β*-bisabolene oxide (19,3%)	
			β-bisabolol B oxide (7,0%)	
			caryophyllene oxide (3,5%)	
	Myrcia platyclada DC	Leaves	stragol (95,0%)	Santana et al.[13]
	(FLORPAN 6631)			
	Plinia cerrocampanensis Barrie	Leaves	*α*-bisabolol (42,3%)	Vila et al.[14]
	(FLORPAN 6623)			Durant et al.[15]
Piperaceae	Piper aduncum L.	Leaves	*β* -caryophyllene (17.4%) aromadendrene (13.4%)	Vila et al.[16]
	(FLORPAN 3264)		*α*-pinene (8,8%)	
			linalool (8,6%)	
			limonene (4,3%)	
	Piper amalago L.	Spikes	2-octanoyl-3-hydroxycyclohex-2-en-1-one (38,9%)	Freixa et al.[17]
	(FLORPAN 3014)		*β*-pinene (26,8%)	
			2-hexanoyl-3-hydroxycyclohex-2-en-1-one (14,6%)	
			α-pinene (11,5%)	
		Stems	2-octanoyl-3-hydroxycyclohex-2-en-1-one (74,7%)	Freixa et al.[17]
			β-pinene (3,8%)	
			2-hexanoyl-3-hydroxycyclohex-2-en-1-one (11,1%)	
			'2-Decanoyl-3-hydroxycyclohex-2-en-1-one (3,2%)	
		Branches	α-thujone (4,1%)	Freixa et al.[17]
			2-octanoyl-3-hydroxycyclohex-2-en-1-one (64,8%)	
			2-hexanoyl-3-hydroxycyclohex-2-en-1-one (9,0%)	
		Leaves	2-octanoyl-3-hydroxycyclohex-2-en-1-one (41,8%)	Freixa et al.[17]
			α-selinene (9,5%)	
			β-bisabolene (7,3%)	

Table Continued

Family	Species	Plant part	Main components	Reference
			2-hexanoyl-3-hidroxycyclohex-2-en-1-one (7,7%)	
			β-caryophyllene (4,9%)	
			β-sesquiphellandrene (4,5%)	
	Piper arboreum Aublet	Leaves	*δ*-cadinene (25,8%)	Mundina et al.[18]
	(FLORPAN 2484)		*α*-copaene (7,4%)	
			β-pinene (6,6%)	
			germacrene D (5,3%)	
			6E-nerolidol (5,2%)	
			β-caryophyllene (4,4%)	
			α-pinene (4,3%)	
			α-muurolene (4,2%)	
			sabinene (4,0%)	
	Piper augustum Rudge	Leaves	cembrene 11,7%)	Rodríguez et al.[19]
	(FLORPAN 4654)		cembratrienol 1*(25,4%)	
			cembratrienol 2* (8,6%)	
			α-pinene (6,0%)	
			β-elemene (12,3%)	
			β-caryophyllene (3,8%)	
	Piper corrugatum Kuntze	Leaves	*β*-pinene (26,6%)	Mundina et al.[18]
	(FLORPAN 4653)		*6E*-nerolidol (12,8%)	
			α-pinene (12,2%)	
			p-cymene (8,6%)	
			β-phellandrene (8,2%)	
			1,8-cineole (5,9%)	
			α-phellandrene (4,7%)	
			linalool (4,2%)	
	Piper curtispicum C.DC.	Leaves	*α*-pinene (19,4%)	Rodríguez et al.[19]
	(FLORPAN 3263)		*β*-caryophyllene (13,9%)	
			limonene (8,1%)	
			δ-cadinene (3,7%)	
	Piper darienense C.DC.	Leaves	*trans*-*β*-farnesene (63,7%)	Rodríguez et al.[19]
	(FLORPAN 4643)		limonene (6,3%)	
			camphene (3,4%)	
			p-cymene (3,3%)	
	Piper fimbriulatum C.DC.	Leaves	germacrene D (12,8%)	Mundina et al.[18]
	(FLORPAN 2479)		*β*-caryophyllene ((11,3%)	
			linalool (5,3%)	
			linalyl acetate (5,3%)	
	Piper friedrichsthalii	Leaves	11-selin-4-*α*-ol (12,8%)	Vila et al.[20]
	(FLORPAN 3107)		*α*-selinene (12,0%)	
			β-selinene (7,9%)	
			germacrene D (9,6%)	
			β-caryophyllene (4,3%)	
			spathulenol (4,3%)	

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Table Continued

Family	Species	Plant part	Main components	Reference
			δ-cadinene (4,2%)	
			α-copaene (3,3%)	
	Piper grande Vahl.	Leaves	*p*-cymene (43,9%)	Rodríguez et al.[19]
	(FLORPAN 6653)		*β*-pinene (14,5%)	
			γ-terpinene (8,0%)	
			α-pinene (6,3%)	
	Piper hispidum Sw.	Leaves	dillapiol (57,7%)	Rodríguez et al.[19]
	(FLORPAN 3266)		piperitone (10,0%)	
			β-caryophyllene (4,3%)	
	Piper jacquemontianum Kunth.	Leaves	linalool (14,5%)	Rodríguez et al.[19]
	(FLORPAN 6611)		*α*-phellandrene (13,8%)	
			limonene (12,2%)	
			β-pinene (10,1%)	
			α-pinene (9,6%)	
			p-cymene (7,4%)	
			6E-nerolidol (4,6%)	
	Piper longispicum C.DC.	Leaves	*β*-caryophyllene (45,2%)	Rodríguez et al.[19]
	(FLORPAN 3265)		*α*-copaene (3,4%)	
			caryophyllene oxide (5,5%)	
			spathulenol (3,8%)	
			germacrene D (3,3%)	
	Piper marginatum Jacq	Leaves	isosafrol (34,4%)	Santana et al.[6]
	(FLORPAN 8367)		myristicin derivative (10,7%)	
			γ-terpinene (10,5%)	
	Piper multiplinervium C.DC.	Leaves	linalool (16,5%)	Rodríguez et al.[19]
	(FLORPAN 6610)		*α*-phellandrene (11,8%)	
			limonene (11,4%)	
			p-cymene (9,4%)	
			β-pinene (7,9%)	
			α-pinene (7,1%)	
			6E-nerolidol (5,5%)	
	Piper obliquum Luis Lopez & Pavón	Leaves	*β*-caryophyllene (27,6%)	Rodríguez et al.[19]
	(FLORPAN 2480)		spathulenol (10,6%)	
			caryophyllene oxide (8,3%)	
			α-copaene (5,6%)	
			β-bisabolene (4,5%)	
			germacrene D (3,9%)	
	Piper reticulatum L.	Leaves	*β*-selinene (19,0%)	Rodríguez et al.[19]
	(FLORPAN 3109)		*β*-elemene (16,1%)	
			α-selinene (15,5%)	
			spathulenol (6,1%)	

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Table Continued

Family	Species	Plant part	Main components	Reference
	Piper trigonum C.DC.	Leaves	germacrene D (19,7%)	Rodríguez et al.[19]
	(FLORPAN 3267)		α-copaene (6,0%)	
			β-elemene (8,4%)	
			δ-cadinene (7,2%)	
			β-caryophyllene (7,1%)	
			α-cadinol (5,8%)	
			γ-muurulene (3,7%)	

Table 3 shows the name of the species, family, and biological activity

Family	Species	Plant part	Biological activity	Reference
Lauraceae	*Protium confusum* (Rose) Pittier	Leaves	*Sa*: 62.5µg/mL	Santana et al.[7]
	(FLORPAN 2932)		*Ms*: 62.5µg/mL	
			No active: *Ca, Ec, Kp, Sg, Pa*.	
			Active against *Aedes aegypti*	
			(LC_{100}:250µg/m)	
		Fruits	Inactive against: *Sa, Ms, Ca, Ec, Kp, Sg, Pa*	Santana et al.[7]
			No active against *Aedes aegypti* (LC_{100}:500µg/mL)	
		Bark	*Sa*: 500µg/mL	Santana et al.[7]
			Ms: 500µg/mL	
			Inactive against: *Ca*, *Ec*, *Kp*, *Sg*, *Pa*	
			Active against *Aedes aegypti*	
			(LC_{100}:125µg/mL)	
		Stem	*Sa*: 500 µg/mL	Santana et al.[7]
			Ms: 500µg/mL	
			Inactive against: *Ca*, *Ec*, *Kp*, *Sg*, *Pa*	
			No active against *Aedes aegypti* (LC_{100}:500µg/mL)	
Myrtaceae	*Calyptranthes hylobates* Standl. Ex. Amshoff	Leaves	Disminution of elongation of lettuce seeds germination (250µg/mL)	Santana et al.[10]
	(FLORPAN 8852)			
	Calyptranthes microphylla B. Holts & M.L.	Leaves	Inactive against: *Sa*, *Bs*, *Pa*, and *Ksp*.	Santana et al.[11]
	(FLORPAN 8843)			
	Eugenia acapulcensis Steud	Leaves	Strong antibacterial	Vila et al.[12]
	(FLORPAN 2630)		Active against Sa and Ms at a concentration of 1,000µg/mL; the MIC=125 and 250µg/mL, respectively.	
			Inactive against *A. aegypti*	
	Eugenia octopleura Krug & Urb	Leaves	Inactive against: *Sa*, *Bs*, *Pa* and *Ksp*.	Santana et al.[11]
	(FLORPAN 8548)			
	Plinia cerrocampanensis Barrie	Leaves	*Ec*: > 1000µg/mL	Vila et al.[14]
	(FLORPAN 6623)		*Sa*: 125µg/mL	Durant et al.[15]
			Ms, *Ca*, *Kp*, *Sg*: 1000µg/mL	
			Pa: 62,5 µg/mL	
			Ca. Ct, *Sc*, *Cn*, *Afl*, *Ani*, *Afu*, *Mc*, *Ef* CIM >250µg/mL	
			Mg: 125µg/mL	

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Table Continued

Family	Species	Plant part	Biological activity	Reference
			Tr. 62,5µg/mL	
			Tm: 32µg/mL	
			larvicidal activity = 10 µg/mL	
			Anti-*Helicobacter pylori* activity: 0.1µg/mL	
	Myrcia aff *fosteri* Croat	Leaves	Good activity against *Sa* and *Bs;*	Santana et al.[11]
	(FLORPAN 8544)		Inactive against Gram negative bacteria Pa and Ksp	
Piperaceae	*Piper aduncum* L.	Leaves	Inactive *in vitro* against seven cancer cell-lines: (M-14, DU-145, ME-180, H460, MCF-7, K562, HT-29) but was not toxic	Vila et al.[16]
	(FLORPAN 3264)			Arroyo et al.[25]
	Piper amalago L.	Stems	2-Hexanoyl-3-hydroxycyclohex-2-en-1-one (75 mg) showed the highest activity against *C. albicans* and *S. cerevisiae*.	Freixa et al.[17]
	(FLORPAN 3014)		2-Octanoyl-3-hydroxycyclohex-2-en-1-one (230mg) was the most active against *C. lacto-condensi*.	
			2-Decanoyl-3-hydroxycyclohex-2-en-1-one (35mg)	
			showed activity against *C. lacto-condensi*.	
	Piper augustum Rudge	Leaves	Moderate biological activity against *Artemia salina*.	Rodríguez et al.[19]
	(FLORPAN 4654)			Delgado et al.[26]
	Piper curtispicum C.DC.	Leaves	Inactive against *Aedes aegypti*	Rodríguez et al.[19]
	Leaves		LC_{100}>500µg/mL	
	(FLORPAN 3263)			
	Piper darienense C.DC.	Root	Pipercallosine, showed, local anesthetic activity	Rodríguez et al.[19]
	(FLORPAN 4643)			
	Piper fimbriulatum C.DC.	Leaves	Active against *Aedes aegypti* (6.25mg/mL) and Active against *Plasmodium falciparum* (11mg/mL) and at 150mg/mL against *Aedes aegypti*	Mundina et al.[18]
	(FLORPAN 2479)			Calderón et al.[27]
	Piper grande Vahl.	Leaves	Inactive against: *Ec*, *Sa*, *Kp*, *Ms*, *Ca*, *Sg*, *Pa* and against fungal strains. Inactive against *Plasmodium falciparum*	Rodríguez et al.[19]
	(FLORPAN 6653)			Mitscher et al.[21]
				Ríos et al.[28]
				Calderon et al.[27]
	Piper hispidum Sw.	Leaves	Active against *Aedes aegypti* (LC_{100}=250µg/mL)	Rodríguez et al.[19]
	(FLORPAN 3266)			
	Piper jacquemontianum Kunth.	Leaves	Inactive against bacterial and fungal strains tested	Rodríguez et al.[19]
	(FLORPAN 6611)			Mitscher et al.[21]
				Ríos JL et al.[28]
	Piper longispicum C.DC.	Leaves	Active against *Aedes aegypti* (LC_{100}=250µg/mL)	Rodríguez et al.[19]
	(FLORPAN 3265)			
	Piper multiplinervium C.DC.	Leaves	Inactive against bacterial and fungal strains tested.	Santana et al.[14]
	(FLORPAN 6610)		Inactive against *Aedes aegypti*.	
			Inactive against bacterial and fungal. Active against *H. pylori* (IC_{50}=0.1µg/mL)	
	Piper reticulatum L.	Leaves	Inactive against *Aedes aegypti* (LC_{100}>500µg/mL).	Rodríguez et al.[19]
	(FLORPAN 3109)			
	Piper trigonum C.DC.	Leaves	Inactive against *Aedes aegypti* and *Sa*, *Ec*, *Kp*, *Pa*, *Ms*.	Rodríguez et al.[19]
	(FLORPAN 3267)			

*Ec, Escherichia coli; Sa, Staphylococcus aureus; Kp, Klebsiella pneumoniae; Kps, Klebsiella sp; Ms, Mycobacterium smegmatis, Ca, Candida albicans; Sg, Salmonella gallinarum; Pa, Pseudomonas aeruginosa*not active (> 1000µg/mL).

Ct, Candida tropicalis; Sc, Saccharomyces cerevisiae; Cn, Cryptococcus neoformans; Afl, Aspergillus flavus; Ani, Aspergillus niger; Afu, Aspergillus fumigatus; Mg, M gypseum; Mc, M canis; Tr, T rubrum, Tm, T mentagrophytes; Ef, E floccosum

Discussion and conclusions

It is interesting to note that many essential oils (EOs) are new and many have very high percentages of chemical constutuents and some are mainly constituted by a single component, for example estragol (95%) in *Myrcia platicada*, methyl eugenol (78.7%) in *Ocimum basilicum* has use as a flavouring aganet in confectionery, icecreams and other food items. It is also an attractant of male insects and has been used in programs of monitoring and control of insects.[29] *Protium confusum* has varied concentration of components in oils from different plant parts. In the EO from the stems limonene (60.2%) is the principal component. EO from the leaves was the most active against *Staphylococcus aureus* and *Mycobacterium smegmatis*, (MIC=62.5µg/mL). EO from the bark was active against *Aedes aegypti* (LC_{100}=125µg/mL).[7] Most of our work has concentrated on more prevalent species of Myrtaceae and Piperacae. EO from leaves of *Myrcia platyclada* was active againts *Helicobacter pylori* at a concentration of 0.1µg/mL. This species was rich in stragole which has acaricidal, analgesic, antibacterial and anti-inflammatory activities. In addition, it finds application in perfumery and as a flavoring agent.[13] EO of *Plinia cerrocampanensis* is an excellent source of *α*-bisabolol (42.8%), and showed activity against *Aedes aegypti*, and bacterial and fungal strains tested. The strongest activity was against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Microsporum gypseum*, *Trichophyton mentagrophytes* and *Trichophyton rubrum* (MIC=32 to 125µg/mL). EO also was active against three strains of *Helicobacter pylori* (MIC and MBC 62.5µg/mL) and at a concetration of 500µg/mL caused 100% mortality of *A. aegypti*.[12] EO of *P. cerrocampanensis* at a concentration <10µg/mL showed activity against *Plasmodium falciparum*. This effect was synergistic when tested in combination with chloroquine.[15] EO of *Calycolpus warszewiczianus* has been also studied in Costa Rica and the sesquiterpenes were the principal components (61,2%vs. 85.1%in Panama sample).[30]

The main components of EO of *Eugenia principium* have shown antimicrobial, larvicidal and anti-inflammatory activieties.[11] EO from the leaves of *Calyptranthes hylobates* has carotol (29.8%), elemicine (23.7%), and myristicine (18.0%) and this species has been studied for the first time. EO showed inhibitory activity of seed germination of *Lactuca saliva*.[10] EO from 18 species of Piper (Piperaceae) have been studied and the results are summarized in a review.[30] Larvicidal activity against *A. aegypti of* six essential oils was tested. Only two EOs from *P. hispidum* and *P. longispicum* were active (LC_{100}=250µg/mL).[19] *P. curtispicum*, *P. multiplinervium*, *P. reticulatum* and *P. trigonum* were inactive ($LC_{100}\geq$500µg/mL). The essential oils of *P. grande*, *P. jacquemontianum*, and *P. multiplinervium* showed o significant antifungal activity (MIC>250µ/mL) against several yeasts and filamentous fungal strains. EOs from different parts of *Protium confusum* show antimicrobial activities against *Staphylococcus aureus* and *Mycobacterium smegmatis*, EO from the leaves being the most active (62.5µg/mL).

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Conflict of interest

The author declares that there is no conflict of interest.

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